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CONTRACTING ORGANIZATION: The Nature Conservancy
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Introduction

Fire is an important ecological process in the southern United States, and elsewhere in the country. Many animal and plant species evolved in the presence of fire, and many vegetation types are maintained by fire. In the past 75 years, with modern fire suppression efforts, as well as expanding roads and development, fire is occurring much less frequently. Fire-dependent biota and communities are threatened and declining as a consequence. Pine Bluff Arsenal has been working to restore pine savanna, a habitat particularly in need of management, by re-introducing prescribed fire on parts of the Arsenal.

The following annual report describes the ecology and history of fire at PBA and lists specific biota and communities being restored by fire. During 2002 The Nature Conservancy initiated the first year of a two-year survey of the herpetofauna at Pine Bluff Arsenal (PBA), to determine if natural resource management activities associated with pine savanna restoration are impacting on amphibian and reptile species, and to add any new species to the inventory list. The 2002 interim report "Effects of Savanna Restoration on Abundance and Diversity of the Amphibians and Reptiles at Pine Bluff Arsenal" is submitted. Fire effects monitoring reports from 2002 are also submitted.

Rationale for Fire Management at Pine Bluff Arsenal Pine Savanna Restoration Project

Site: Pine Bluff Arsenal Old Growth and Pine Savanna Restoration Areas: ~2500 acres.

Location: Sections 18, 22, and 24, R10W T5S; Sections 13 and 14, R10W T5S; Jefferson County, Arkansas.

Ownership: Department of Defense; TNC - Fire Management Contract.

Update: March 9, 2003; Lance Peacock and Mike Melnechuk.

General Site Description:

The 15,000 acre Pine Bluff Arsenal landscape is a mix of arsenal facilities, urbanized areas, second growth upland forest (11,000 acres), old fields and rights-of-way maintained by mowing and fire, bayous with riparian forest, lakes, swamps, and ponds. The arsenal is located on the West Gulf Coastal Plain along the Arkansas River. The geologic formations are deep alluvial deposits composed of sand and silt with embedded clay and gravel layers and wind deposited loess. The landscape is generally flat with little relief except where small creeks and streams have formed deeply incised ravines as they penetrate steep (to 100% slopes) Arkansas River bluffs. The elevation ranges from 195 feet above msl at the Arkansas River to 240 feet above msl at the top of the Arkansas River bluff and to 340 feet above msl at the northwest corner of the base.

The arsenal contains most of the forest communities found on the West Gulf Coastal Plain except the most xeric. Hydric bald cypress strands, mesic riparian forests, mesic to dry pine-oak forests, seeps, grasslands, and dry oak woodlands are extant. Quality ranges from low to high with the bulk of the forested area of medium quality. Many sensitive plants and animals, as well as a wide diversity of common species find suitable habitat on the arsenal. PBA has an active wildlife and timber management program. Five sites on the arsenal have been delineated due to their ecological quality and representativeness and three of these areas have a designated old growth forest components. Additional sites on PBA may be identified for biodiversity management due to continuing ecological assessment and biological inventory.

Refuge Woods: The Refuge woods comprise a spectrum of forest communities ranging from poorly drained hardwood bottoms to moderately well-drained pine-oak uplands. The bottoms are relatively open oak, hickory, sweetgum forests with scattered loblolly pine, and bald cypress in depressions. The trees are tall (70'-80') with 2' dbh common. The understory is mostly deep duff and leaf litter. Small patches of cane, seeps with dense ferns, and vine tangles are extant. The soil is usually moist with standing water in the late winter and spring. In the better drained upland areas the pine component increases with more grasses and areas of thick vine tangles. The litter and duff layers contain pine needles, and are more volatile. Due to small pine beetle infestation, several areas have been heavily thinned and represent pine savanna with dense herbaceous layers. Large standing snags are extant. Two small draws that are brush hogged annually contain rattlesnake master (*Eryngium yuccifolium*) and its dependent rattlesnake master borer moth (*Papaipema eryngii*) an insect previously on the USFWS candidate list.

Eastwood Bayou: Eastwood Bayou comprises rich riparian forests and slopes along a stream that flows year round and adjacent dry upland oak-pine forests. Although the trees are not as tall or large as refuge woods the herbaceous layer is better developed with more grasses and forbs. The riparian understory contains scattered cane and seeps with ferns. The duff and litter (mostly oak leaves) layer is deep. The uplands are drier with a higher component of pine needles in the litter layer. Vine tangles and woody debris are extant. Several rare plants are known from Eastwood bayou. Much of this site contains munitions storage bunkers.

Triplets Bluff-Phillips Creek: This site contains the driest uplands on the base, as well as a deep ravine with a rich bottomland and slope forests of cherrybark oak and bald cypress. Phillips Creek is a perennial stream with a elm-ash-sugarberry canopy over a rich plant community. The riparian area is often dense with cane and vines. The trees are large and the soils moist. The uplands are mesic to dry oak and oak-pine forests and woodlands. The trees in the uplands are relatively short (50' or less) and small (dbh 18").

Scattered grasses form the herbaceous layer with a mostly oak leaf litter. The duff layer is moderately deep. Several rare plants and the highest quality plant communities are located at this site. Much of this site is in a designated duded area.

Yellow Lake: (see TNC 1997) Not a fire maintained site.

Railroad Grassland: The railroad grassland is a long strip of grass dominated vegetation along the railroad right-of-way. The grassland is dominated by little bluestem, velvet panic grass, and a wide diversity of the forbs and grasses. Several rare plants are known from the railroad grassland. In places the site has become shrubby with small tress

Elements Of Conservation Concern:

The following list is composed of plant communities and plant and animal species of conservation concern known from the Pine Bluff Arsenal. Not all plant communities and plant and animal species are known from the old growth areas. Recent biological inventories uncovered many species of insects that had not been recorded from Arkansas. Several are considered rare but have not been ranked and are not included in the following table.

Plant communities:		
mixed overstory- <i>Arundinaria gigantea</i> Riparian	forested canebrake	G2S S1
mixed overstory- <i>Acer rubrum</i> var. <i>trilobum</i> -fern Forest	coastal plain seeps	G4 S2S3
<i>Pinus echinata</i> - <i>Quercus (stellata-falcata)</i> Woodland	dry shortleaf pine-oak woodland	G4 S4
<i>Pinus (taeda-echinata)</i> - <i>Quercus (velutina-falcata-alba)</i> Forest	submesic pine-oak forest	G3 S1
<i>Pinus taeda</i> - <i>Quercus (nigra-alba)</i> Forest	lowland pine-oak forest	G2 S1
<i>Pinus taeda</i> Savanna	pine savanna	G3 S1
<i>Quercus lyrata</i> Forest	overcup oak forest	G4 S3
<i>Quercus (nigra-alba)</i> - <i>Carya cordiformis</i> Forest	mesic oak forest	G4 S4
<i>Quercus (pagoda-alba)</i> - <i>Liquidambar styraciflua</i> Forest	lowland oak-sweetgum forest	G3G4 S1
<i>Quercus phellos</i> Forest	willow oak forest	G3 S2
<i>Quercus stellata</i> - <i>Quercus (velutina-marilandica)</i> Woodland	dry oak woodland	G3 S2
<i>Schizachyrium scoparium</i> - <i>Panicum anceps</i> Grassland	tallgrass prairie	G4 S4
<i>Taxodium distichum</i> Forest	bald cypress forested channel	G4 S3
<i>Ulmus americana</i> - <i>Fraxinus pensylvanica</i> - <i>Celtis laevigata</i>	Forestelm-ash-sugarberry forest	G5 S5
Plants:		
<i>Carex atlantica</i> subsp. <i>capillacea</i>	prickly bog sedge	G5T5 S2S3
<i>Chamaelirium luteum</i>	devil's bit	G5 S3
<i>Eleocharis flavescens</i>	pale spikesedge	G5 SU
<i>Eleocharis microcarpa</i>	small seeded spikesedge	G5 S2
<i>Eupatorium hyssopifolium</i> var. <i>hyssopifolium</i>	boneset	G5 S3
<i>Lycopodium appressum</i>	southern clubmoss	G5 S3
<i>Scleria pauciflora</i>	few flowered nutrush	G5 S3
Animals:		
<i>Alligator mississippiensis</i>	American alligator	G5 S3
<i>Buteo lineatus</i>	red-shouldered hawk	G5 S3
<i>Haliaeetus leucocephalus</i>	bald eagle	G4 S2

<i>Ixobrychus exilis</i>	least bittern	G5 S2
<i>Lophodytes cucullatus</i>	hooded merganser	G5 S2
<i>Macrocllemmys temmincki</i>	alligator snapping turtle	G3 G4 SU
<i>Papaipema eryngii</i>	rattlesnake master borer moth	G1 S1
<i>Regina grahamii</i>	Graham's crayfish snake	G5 S2
<i>Speyeria diana</i>	diana fritillary	G3 S3
<i>Tachycineta bicolor</i>	tree swallow	G5 S4

Role and History of Fire:

Fire in the pine, pine-oak, and oak dominated forests of the southeastern United States has been well documented by Pyne (1982) and others. An examination of Arkansas Forestry Commission records indicates a prevalence of naturally (lightening) ignited fires occurring from mid-July through October in the Interior Highlands and Gulf Coastal Plain with a shorter fire season in March and April. Anthropogenic fire could occur in any season but early records of aboriginal burning reference September through December. Periodic fire is essential to maintaining open forest structure and composition, as well as the herbaceous vegetation in pine, oak-pine, and oak forests and woodlands and associated grassland ecosystems of the Gulf Coastal Plain uplands. Fire also plays a role in maintaining open wetland and oak-dominated bottomland forest communities

Examination of GLO records of the site indicate a forest composition similar to today's but with a more open forest structure. Fire history reconstruction in the Ouachita Mountains show a wide range in frequencies, spatial coverage, and seasonally depending on location, community type, and aspect. Pine, oak, and pine-oak communities on ridges and south slopes with grassy herbaceous layers burned in the range of 1 - 7 year intervals. While north slope and ravine forests burned at less frequent intervals. No fire reconstruction work has been done for Arkansas' Gulf Coastal Plain.

Past Management:

Previous to the establishment of the arsenal in 1941 the area was a mix of farms and forest. The area was cutover for timber before 1920. The flat areas were cultivated and steeper area used as woodlots and grazing for cattle and hogs. Abandoned fields grew up in pine or in some cases were planted in pine during the 1930's. The burning of farm stubble and woodlands was a common practice in Arkansas throughout this time period.

The establishment of the arsenal began a long history of timber and wildlife management under various management philosophies ranging from neglect to active manipulation. Fires were suppressed during much of this time period.

For the last 15-20 years prescribed fire has been used to prevent wildfires along the railroad right-of-way and under pine forests to control the understory and to improve wildfire habitat. Some prescribed burning is carried out every year at PBA. Prescribed forest fires have been relatively cool winter burns and are not usually used in hardwood stands to protect timber value. With the more recent emphasis on biodiversity and ecosystem management attempts are being made to more closely imitate fires that maintain and enhance forest structure and composition.

Goals of Fire Management:

1. The restoration and maintenance of a diverse herbaceous layer in all plant communities represented at PBA.
2. The restoration of a more open, large tree-grass structure in the designated old growth areas across forest types.

3. The restoration of pine savanna.

4. The maintenance and enhancement of fire-dependent rare species populations.

Constraints:

Possible logistical constraints include restricted access to some burn units, nearby munitions storage, duded areas, smoke management, and base operations.

Damage from Fire:

None. Several rare plants, reptiles, birds, and insects are known from PBA. The species of concern are grassland remnant-dependent, fire-dependent, or fire-independent and are expected to increase or not be affected as fire is reintroduced.

Burn Units:

No permanent burn units are in place:

In 1999 three units were burned.

Refuge Woods: pond unit 185 acres. Completed 3/99.

Phillips Creek-Triplets Bluff (bombing mat): dud unit 103 acres. Completed 3/99.

Eastwood Bayou (CLA): bunker unit 98 acres. Completed 11/99

In 2000 one unit was burned and two units are scheduled.

Refuge woods: savanna unit 206 acres. Completed 3/00.

Yellow Lake: island unit – 75 acres.

Eastwood Bayou: pecan grove unit – 60 acres.

In 2001 four units were burned.

Yellow Lake, island unit – 75 acres. Completed 3/01.

Pine Savanna Restoration Area, hourglass unit – 36 acres. Completed 3/01.

Pine Savanna Restoration Area, horseshoe lake unit – 127 acres. Completed 3/01.

Triplett's Bluff, nilo pond unit – 183 acres. Completed 3/01.

In 2002 nine units were burned.

Pond unit – 185 acres. Completed 3/05

Tulley Lake unit – 15 acres. Completed 2/28

Bomb Storage units A-D, 1, 5, and 9 – 77 acres, seven units. Completed 2/28 and 3/4.

Burn Timing and Frequency:

Fire could burn in this landscape in any season. Most prescribed burning in Arkansas is carried out from September through April. Burning in any of these months is appropriate. Growing season (April - September) and pre/post drought burns have very beneficial effects in restoring ecosystem composition and structure.

Restoration burns are used to remove the heavy build up of litter and duff and reduce the density of woody stems in the smaller size classes. During the restoration phase short time intervals (annual to every 2 years)

are desired, dependent on fuel conditions. During the maintenance phase longer time intervals may be desired.

Monitoring:

Post fire estimates of fire intensity (scorch height and class, char, understory burn severity, and litter consumption) will be taken. Permanent transects with photo points will be established to monitor and measure tree densities and plant composition. Observations of rare species reaction to fire management will be noted. The reaction of the rattlesnake borer moth to the timing, frequency, and intensity of burns will be noted.

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Appendix

Effects of Savanna Restoration on Abundance and Diversity of the Amphibians and Reptiles
at Pine Bluff Arsenal
Fire Summary Reports

**EFFECTS OF SAVANNA RESTORATION ON ABUNDANCE AND DIVERSITY OF
THE AMPHIBIANS AND REPTILES
AT PINE BLUFF ARSENAL**



Fiscal Year 2002 Report
February 2003

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ACKNOWLEDGEMENTS

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Cover photographs: top left, marbled salamander photographed by Maria Melnechuk, The Nature Conservancy (TNC); top right, eastern narrowmouth toad photographed by David Gosse, TNC; bottom, speckled kingsnake photographed by David Gosse, TNC.

SUMMARY

The Nature Conservancy-Arkansas Field Office (TNC-ARFO) conducted the first phase of a two-year survey of the herpetofauna at Pine Bluff Arsenal (PBA), to determine if natural resource management activities associated with pine savanna restoration are impacting on amphibian and reptile species, and to add any new species to the inventory list. The goals of the project are:

- 1) to provide data for any changes in general species abundance/diversity from natural resource management activities (mechanical thinning, prescribed fire, and a combination of the two) in association with pine savanna restoration on PBA;
- 2) to make any additions to the species list from the baseline inventory;
- 3) to search for any taxa of amphibians and reptiles that are tracked in the data base of the Arkansas Natural Heritage Commission, and that are known from PBA or adjoining counties, and;
- 4) to report any findings for populations of threatened, endangered, or otherwise significant taxa occurring on PBA.

The principal methodology employed in this survey consisted of the placement of a series of drift fence arrays in three (3) areas of the PBA where recent (~1-2 years) pine savanna restoration management, predominately prescribed fire and selective timber harvest, has occurred. Other survey techniques included road cruising; pond, creek, and lake surveying with binoculars; and opportunistic leaf raking, log rolling, and debris searching.

A total of 32 amphibian and reptile taxa were observed or captured during the 2002 survey period. Data were collected opportunistically, and from six drift fence arrays, during the periods of May 30 to June 7 and July 9 to July 18. During these periods a total of 268 amphibian and reptile captures, and 124 observations were recorded. Mortality due to fire ants, wolf spiders, shrews, and desiccation was recorded on 47 individuals (17.5% of total captures), predominately frogs and toads. One regionally unrecorded species, the mole salamander (*Ambystoma talpoideum*), was captured at drift fence array 5.

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INTRODUCTION

At the request of natural resource managers at Pine Bluff Arsenal (PBA), The Nature Conservancy-Arkansas Field Office (TNC-ARFO) began a two-year survey of amphibians and reptiles on restoration areas at the arsenal. The goals of the project are:

- 1) to provide data for any changes in general species abundance/diversity from natural resource management activities (mechanical thinning, prescribed fire, and a combination of the two) in association with pine savanna restoration on PBA;
- 2) to make any additions to the species list from the baseline inventory;
- 3) to search for any taxa of amphibians and reptiles that are tracked in the database of the Arkansas Natural Heritage Commission, and that are known from PBA or adjoining counties, and;
- 4) to report any findings for populations of threatened, endangered, or otherwise significant taxa occurring on PBA.

Although a survey of amphibians and reptiles was conducted during 1997 (Robison 1997), no extensive herpetological inventorying had been conducted in the restoration areas of PBA.

PINE BLUFF ARSENAL

The Pine Bluff Arsenal is a 13,497-acre Army base owned and managed by the Department of Defense. TNC-ARFO has a fire management and monitoring contract with PBA, under which the herpetological survey is being conducted. Over 8,000 acres of the base are considered forested. The arsenal contains most of the forest communities found on the Upper West Gulf Coastal Plain, with the exception of the most xeric. Hydric bald cypress strands, mesic riparian forests, mesic to dry pine-oak forests, seeps, grasslands, and dry oak woodlands are extant. Quality ranges from low to high with the bulk of the forested area of medium quality. Many sensitive plants and animals, as well as a wide diversity of common species find suitable habitat on the arsenal (Peacock and Simon 2002).

PBA has active wildlife, timber, and fire management programs in place, with between 300 to over 1000 acres being burned annually on the base. Fire management, in conjunction with selective tree harvest, is being utilized to restore pine savanna on the base. Pine savanna in the coastal plain of Arkansas is characterized by widely scattered, relatively old loblolly or shortleaf pine with little to no midstory component and a diverse herbaceous understory.



Figure 1. Example of pine savanna restoration area near Horseshoe Pond.



Figure 2. Pine savanna restoration area in Refuge Woods at array 1.

The main goal of this study is to monitor ecosystem response (amphibians and reptiles) at selected restoration areas. It is important for managers to know what impacts these restoration activities are having on the herpetofauna, important components of natural communities, on PBA. The drift fence arrays used during this survey will be left in place to allow for future herpetological sampling, following continued restoration efforts.

Table 1. Elements of Conservation Concern: Pine Bluff Arsenal

Plant communities:		
mixed overstory- <i>Arundinaria gigantea</i> Riparian Forest	forested canebrake	G2 S1
mixed overstory- <i>Acer rubrum</i> var. <i>trilobum</i> -fern Forest	coastal plain seeps	G4 S2S3
<i>Pinus echinata-Quercus (stellata-falcata)</i> Woodland	dry shortleaf pine-oak woodland	G4 S4
<i>Pinus (taeda-echinata)-Quercus (velutina-falcata-alba)</i> Forest	submesic pine-oak forest	G3 S1
<i>Pinus taeda - Quercus (nigra-alba)</i> Forest	lowland pine-oak forest	G2 S1
<i>Pinus taeda</i> Savanna	pine savanna	G3 S1
<i>Quercus lyrata</i> Forest	overcup oak forest	G4 S3
<i>Quercus (nigra-alba) - Carya cordiformis</i> Forest	mesic oak forest	G4 S4
<i>Quercus (pagoda-alba) - Liquidambar styraciflua</i> Forest	lowland oak-sweetgum forest	G3G4 S1
<i>Quercus phellos</i> Forest	willow oak forest	G3 S2
<i>Quercus stellata-Quercus (velutina-marilandica)</i> Woodland	dry oak woodland	G3 S2
<i>Schizachyrium scoparium-Panicum anceps</i> Grassland	tallgrass prairie	G4 S4
<i>Taxodium distichum</i> Forest	bald cypress forested channel	G4 S3
<i>Ulmus americana-Fraxinus pensylvanica-Celtis laevigata</i> Forest	elm-ash-sugarberry forest	G5 S5
Plants:		
<i>Carex atlantica</i> subsp. <i>capillacea</i>	prickly bog sedge	G5T5 S2S3
<i>Chamaelirium luteum</i>	devil's bit	G5 S3
<i>Eleocharis flavescens</i>	pale spikesedge	G5 SU
<i>Eleocharis microcarpa</i>	small seeded spikesedge	G5 S2
<i>Eupatorium hyssopifolium</i> var. <i>hyssopifolium</i>	boneset	G5 S3
<i>Lycopodium appressum</i>	southern clubmoss	G5 S3
<i>Scleria pauciflora</i>	few flowered nutrush	G5 S3
Animals:		
<i>Alligator mississippiensis</i>	American alligator	G5 S3
<i>Buteo lineatus</i>	red-shouldered hawk	G5 S3
<i>Crotalus horridus</i>	timber rattlesnake	G4 S4
<i>Haliaeetus leucocephalus</i>	bald eagle	G4 S2
<i>Ixobrychus exilis</i>	least bittern	G5 S2
<i>Lophodytes cucullatus</i>	hooded merganser	G5 S2
<i>Macrolemmys temmincki</i>	alligator snapping turtle	G3G4 SU
<i>Papaipema eryngii</i>	rattlesnake master borer moth	G1 S1
<i>Rana areolata</i>	crawfish frog	G4 S2
<i>Regina grahamii</i>	Graham's crayfish snake	G5 S2
<i>Speyeria diana</i>	diana fritillary	G3 S3
<i>Tachycineta bicolor</i>	tree swallow	G5 S4

MATERIALS AND METHODS

DRIFT FENCE/FUNNEL TRAP AND PITFALL TRAP ARRAY SURVEY

The principal methodology employed in this survey consisted of the placement of a series of drift fence arrays within three areas of PBA where recent (~1 to 2 years) pine savanna restoration management, predominately prescribed fire and selective timber harvest, has occurred. We also included a "control" array in each of the delineated areas to sample habitat that had not been exposed to any restoration efforts.

Site Selection

Aerial photographs from 2001 were obtained from Natural Resource Manager Charles Becker. U.S. Geological Survey (USGS) topographical maps, TNC-ARFO prescribed burn unit maps, and guidance from Mr. Becker were used to identify herpetological sampling sites on the arsenal. A preliminary visit to the arsenal was made in May by Melnechuk and Peacock, to discuss with Mr. Becker the scope of work and site selection for trap installation. Criteria for site selection included: prescribed burn history, mechanical thinning history, amount of canopy closure, and projected installation time. We then selected nine sites for drift fence arrays (Appendix A). Due to time constraints and budgetary limitations seven arrays were ultimately installed during 2002, with data being recorded for arrays 1-6 (Fig. 1-4). The final two arrays are expected to be installed in the spring of 2003.

Installation

The drift fences were constructed from rolls of silt fencing measuring 61 cm wide by 30.5 m long. Pulaski axes and fire rakes were used to dig a shallow trench for fence installation, and chainsaws, brushcutters, and a bush-hog were utilized in heavier brush for clearing a path for the arrays. Fencing was staked in place and the bottom edge was covered with dirt and debris to prevent animals from crawling beneath the fence. All seven arrays were constructed in a "T" pattern (i.e., one 30.5-m section of fence adjoined at a central point with another 30.5-m section of fence at a 90-degree angle).

All drift fence arrays were fitted with one funnel trap at the end of each arm, and a pitfall trap in the middle of each arm, for a total of three funnel traps and three pitfall traps per array. The funnel traps were constructed of aluminum window screen and measured 100 cm long by 30 cm in diameter, and had a funnel opening at one end. The pitfall traps were 19-liter plastic buckets that were buried into the ground underneath the fence arms, with the open end of the bucket flush with the ground surface. Small holes were drilled into the lower side-walls of the buckets to drain water, and lids were placed onto the buckets when not active, to prevent mortality.

Data Collection

Traps were set at the drift fence arrays as soon as the arrays were installed. All traps were completely shaded with vegetation found at each site (e.g., grass, pine boughs, pine straw, etc.). Traps were checked at two-day intervals during the first part of the study. Due to some mortality from fire ants and desiccation, traps were then checked every day, and shut down whenever they could not be checked within two days. For each individual captured we recorded the location, date, species, and estimated age of the individual. Opportunistic observations were also recorded while travelling the roadways, from ditches, creeks, etc., and while walking into the array areas. A list of these observations is included in the herpetofaunal database under the heading "OBS" (Appendix C).

RESULTS

DRIFT FENCE SURVEY

Trapping efforts commenced as soon as each array was installed. Arrays 1 - 4 were installed May 30 and 31 and were set for 21 nights during June and July. Arrays 5 - 7 were installed on July 2 and were set for 12 nights. Data collected from array 7 was discontinued as it was the only array set in the Triplett's Bluff area. Data collection will resume at this site when arrays 8 and 9 are installed. Initial plans were to keep the drift fences open continuously for 30 nights. Due to access limitations, potential mortality issues, and installation length of time, this was not achieved.

Brief descriptions and photographs of the drift fence sites are as follows:



Figure 3. Array 1 - Pine savanna restoration area.

Array 1 – Pine savanna restoration area at the northwest corner of Refuge Woods site. About 30 acres of recently thinned loblolly and shortleaf pine. A recent (February, 2002) moderately-intense prescribed fire consumed much of the smaller downed woody debris, and top-killed most of the young hardwood shrubs. Larger pieces of downed woody debris remain. The herbaceous layer has responded well and is intact.



Figure 4. Array 2 – Hardwood restoration area.

Array 2 – Hardwood restoration area at the southeast corner of the base. A recent thinning operation has removed all of the larger pines and the midstory and left many of the older hardwoods, predominately *Quercus* spp. The ground cover has been somewhat disturbed, and there is much downed woody debris. The herbaceous layer is responding to the increased sunlight.



Figure 5. Array 3 – Control array.

Array 3 – Control array, located to the north of the hardwood restoration site. This area comprises unthinned and unburned, relatively old, second-growth pine-oak forest. There is a dense midstory. The understory is mostly deep duff and leaf litter, with no real herbaceous component. Many thick vine tangles are present.



Figure 6. Array 4 – Pine savanna restoration area.

Array 4 – Pine savanna restoration area located to the south of Horseshoe Pond. This area has been thinned leaving widely-spaced, mature loblolly pines with a primarily herbaceous and shrub component in the understory, and no midstory. A recent prescribed burn (March, 2001) has top-killed many of the hardwood shrubs, although many are growing back.

Array 5 – Pine savanna restoration area located across the fireline from array 4. This area is similar in structure to array 4, but did not have the prescribed fire. The hardwood shrubs are a little more dense and taller than around array 4, with more leaf litter and duff on the ground.

Array 6 – Control array. Relatively open pine-oak flatwoods that have been neither burned nor thinned. The site is located off the road from Tulley Lake to Horseshoe Pond. Depending on rainfall, this site can range from almost hydric to dry, with the soil turning to hardpan in times of low rainfall. Mature loblolly pines are interspersed with willow oak and water oak. The midstory has relatively few shrubs with a pine needle and leaf litter ground cover.

During the drift fence surveys, 392 amphibians and reptiles representing 32 taxa were captured or observed (Table 2). One regionally unrecorded species, the mole salamander (*Ambystoma talpoideum*), was captured at array 5 on July 13. Mortality was recorded on 47 individuals (17.5% of total captures), predominately frogs and toads that were over-exposed to the heat, or were consumed by fire ants. Several shrew, mice, rat, vole, and insect species were also caught in the trapping process. The location(s) and method(s) of observation of all amphibian and reptile species documented during the survey are listed in Table 2.

Table 2. Amphibian and reptile species observed at Pine Bluff Arsenal during the 2002 herpetological survey

Scientific name	Common name	Method of observation*	Capture arrays	# of captures/ observations
Crocodilians				
<i>Alligator mississippiensis</i>	American alligator	c		4
Turtles				
<i>Chelydra serpentina</i>	Snapping turtle	c		1
<i>Pseuemyd concinna</i>	River cooter	c		1
<i>Terrapene carolina</i>	Three-toed box turtle	c		29
<i>Trachemys scripta</i>	red-eared slider	c		6
Lizards				
<i>Cnemidophorus sexlineatus</i>	Racerunner	c		5
<i>Eumeces anthracinus</i>	Southern coal skink	c		1
<i>Eumeces fasciatus</i>	five-lined skink	a, b, c	2, 3, 6	8
<i>Scincella lateralis</i>	Ground skink	a, b, c	1, 2, 3	20
<i>Sceloporus undulatus</i>	Northern fence lizard	a, c	1, 4	10
Snakes				
<i>Agkistrodon piscivorus</i>	Cottonmouth	c		2
<i>Coluber constrictor</i>	Southern black racer	a, c	2	6
<i>Elaphe obsoleta</i>	Black rat snake	a, c	1	4
<i>Lampropeltis calligaster</i>	Prairie kingsnake	a	4	1
<i>Lampropeltis getula</i>	Speckled kingsnake	a	1	1
<i>Nerodia erythrogaster</i>	Yellowbelly water snake	a, c	4	3
<i>Opheodrys aestivus</i>	Rough green snake	c		2
<i>Thamnophis proximus</i>	Western ribbon snake	a, c	5, 6	8
<i>Thamnophis sirtalis</i>	Eastern garter snake	c		1

Scientific name	Common name	Method of observation*	Capture arrays	# of captures/ observations
<i>Virginia striatula</i>	Rough earth snake	a	2, 4	2
Salamanders				
<i>Ambystoma maculatum</i>	Spotted salamander	a	1, 2, 3	5
<i>Ambystoma opacum</i>	Marbled salamander	a, b, c	1, 2, 3, 4	6
<i>Ambystoma talpoideum</i>	Mole salamander	b	5	1
Frogs and Toads				
<i>Acris crepitans</i>	Northern cricket frog	a, b, c	1, 2, 4, 5	14
<i>Bufo americanus charlesmithii</i>	Dwarf American toad	a, b, c	1, 2, 3	13
<i>Bufo woodhousii fowleri</i>	Fowler's toad	a, b, c	1, 2, 3	25
<i>Gastrophryne carolinensis</i>	Eastern narrowmouth toad	a, b	1, 2, 3, 4, 6	42
<i>Pseudacris crucifer</i>	Spring peeper	a	1	2
<i>Pseudacris triseriata feriarum</i>	Upland chorus frog	c		4
<i>Rana catesbeiana</i>	Bullfrog	c		10
<i>Rana clamitans</i>	Bronze frog	a, b, c	1, 2, 3	17
<i>Rana utricularia</i>	Southern leopard frog	a, b, c	1, 2, 3	128

* a = captured in funnel trap, b = captured in pit-fall trap, c = opportunistic observations

SUMMARY OF RESULTS

The results of the study can not be considered final at this point in time, as this will be an ongoing project, although they do provide some interesting insights even at this early juncture.

The most productive capture arrays were array 1 (pine savanna restoration area) and array 2 (hardwood restoration area), which together accounted for more taxa captured than the other four arrays combined. Amphibian species were well represented in the study, with six species of frog, three toads, and three salamanders being documented. All amphibian species that were captured in traps were documented from restoration areas of some type (arrays 1, 2, 4, and 5). Control array 3 provided seven species of amphibian, while control array 6 accounted for only one species of amphibian captured, the eastern narrowmouth toad (*Gastrophryne carolinensis*). Array 5 (pine savanna restoration area/thinned/unburned) provided the biggest surprise of the study, a mole salamander (*Ambystoma talpoideum*). This species has not previously been documented from PBA. According to present range maps for the species, it is not found within 100 miles of the base. The southern leopard frog (*Rana utricularia*), comprised almost half of the recorded captures for the study, and was particularly abundant in the hardwood restoration area (array 2) and the pine savanna restoration area at array 1.

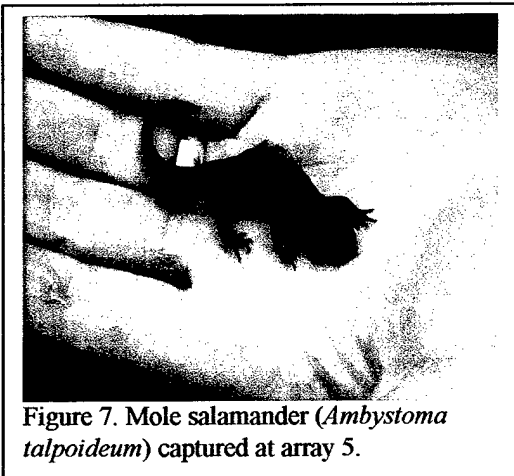


Figure 7. Mole salamander (*Ambystoma talpoideum*) captured at array 5.

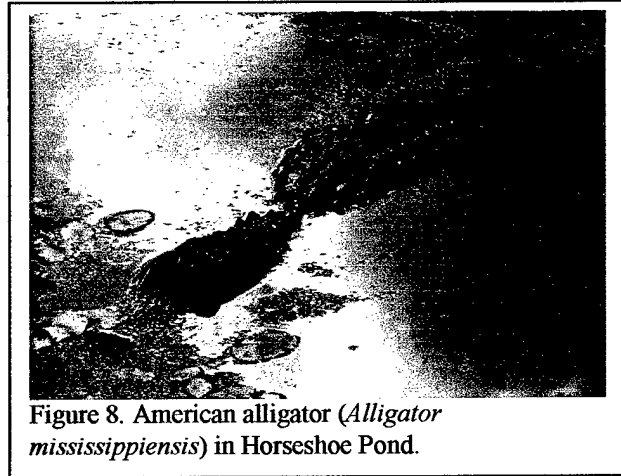


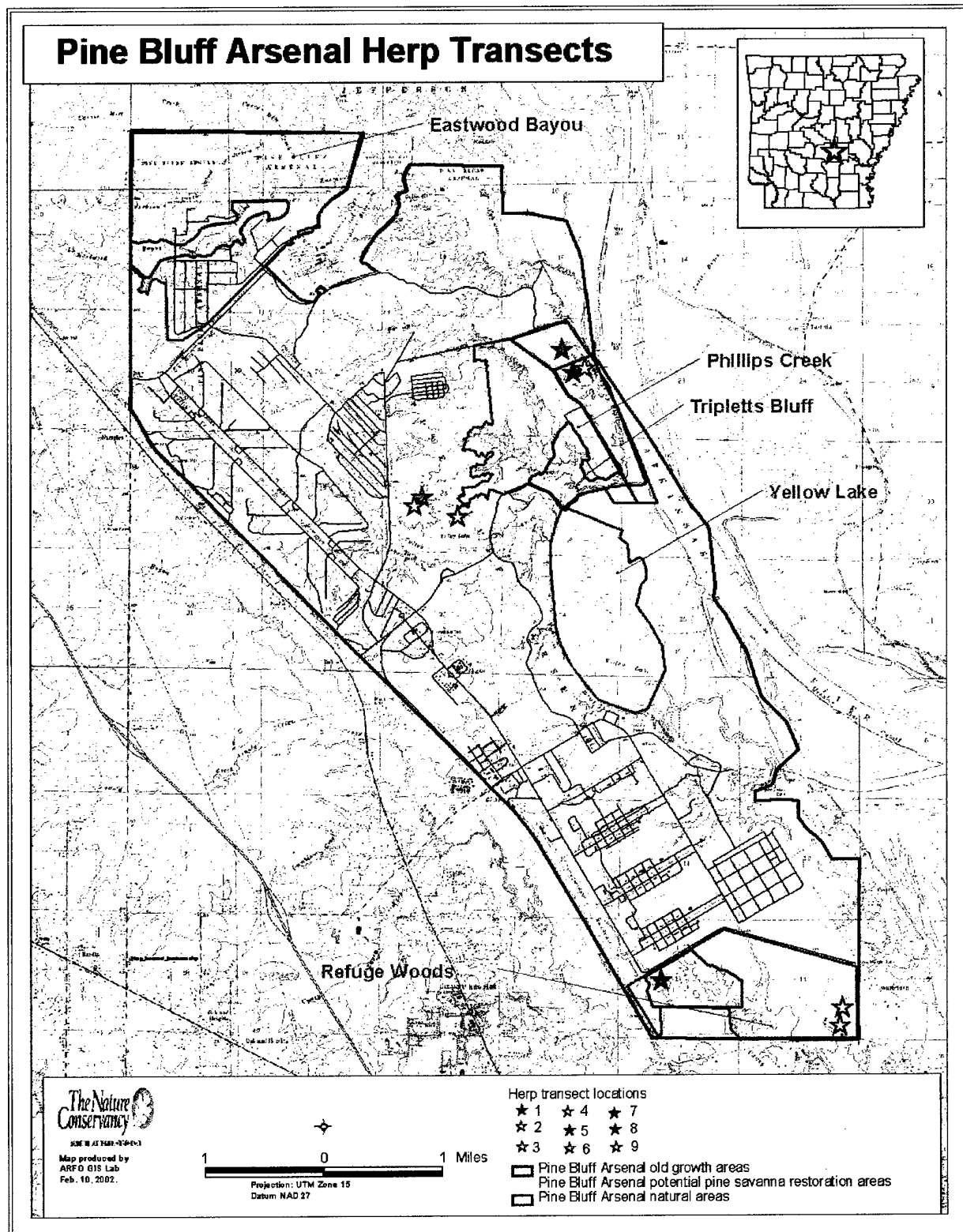
Figure 8. American alligator (*Alligator mississippiensis*) in Horseshoe Pond.

Reptiles were also well represented in the study, with one crocodilian species, four turtles, five lizards, and ten snakes being documented. All reptile species that were captured in traps were documented from restoration areas (arrays 1, 2, 4, and 5). Control array 3 captured two species of reptile, and control array 6 captured two species of reptile as well. Four separate individuals of American alligator (*Alligator mississippiensis*) were documented during the study. Two individuals were found in Horseshoe Pond, a large adult (~3 meters long) and a smaller sub-adult (~1.75 meters long). One individual was documented in Tulley Creek, a small juvenile about 1.5 meters in length. A larger adult individual was also observed to be residing in Clear Pond just to the south of Tulley Creek, whose size was estimated to be over 3 meters in length. The American alligator is federally listed as a threatened species due to similarity of appearance [to other crocodilians] (Federal Register 6 July 1987).

After one inventory, we can only make educated guesses on what the long-term impact that savanna restoration is having on the herpetofauna at PBA. Initial results look promising, in that the restoration activities such as thinning and prescribed fire appear to be having a positive impact on species diversity and abundance. This assumption is made evident by examining the locations where the majority of species were caught (twenty species in restoration areas versus ten species in the control areas), and the sheer numbers of individual species captured in restoration areas (202 individuals captured in restoration areas versus 68 captured in control areas). These are preliminary observations. The study should continue for the next 5-10 years to better determine the relationship between herpetofauna and pine savanna restoration activities.

APPENDIX A.

Locations of drift fence arrays, restoration areas, and rare or significant species collected, 2002.



APPENDIX B.

Four-letter codes for amphibians and reptiles susceptible to capture from drift fence arrays at Pine Bluff Arsenal.

Code: Common and scientific names:

AMPHIBIANS**Anurans**

ACRE	Northern cricket frog (<i>Acris crepitans</i>)
BCHA	Dwarf American toad (<i>Bufo americanus charlesmithii</i>)
BFOU	Fowler's toad (<i>B. woodhousii fowleri</i>)
GCAR	Eastern narrowmouth toad (<i>Gastrophryne carolinensis</i>)
HAVI	Bird-voiced treefrog (<i>Hyla avivoca</i>)
HCHR	Cope's gray treefrog (<i>H. chrysoscelis</i>)
HCIN	Green treefrog (<i>H. cinerea</i>)
PCRU	Spring peeper (<i>Pseudacris crucifer</i>)
PSTR	Strecker's chorus frog (<i>P. streckeri</i>)
PTRI	Upland chorus frog (<i>P. triseriata feriarum</i>)
RARE	Crawfish frog (<i>Rana areolata</i>)
RCAT	Bullfrog (<i>R. catesbeiana</i>)
RCLA	Bronze frog (<i>R. clamitans</i>)
RPAL	Pickerel frog (<i>R. palustris</i>)
RUTR	Southern leopard frog (<i>R. utricularia</i>)
SHOL	Eastern spadefoot toad (<i>Scaphiopus holbrookii</i>)
SHUR	Hurter's spadefoot toad (<i>S. holbrookii hurterii</i>)

Salamanders

AMAC	Spotted salamander (<i>Ambystoma maculatum</i>)
AOPA	Marbled salamander (<i>A. opacum</i>)
ATAL	Mole salamander (<i>A. talpoideum</i>)
ATEX	Smallmouth salamander (<i>A. texanum</i>)
ATIG	Eastern tiger salamander (<i>A. tigrinum</i>)
ATRI	Three-toed amphiuma (<i>Amphiuma tridactylum</i>)
EQUA	Dwarf salamander (<i>Eurycea quadridigitata</i>)
HSCU	Four-toed salamander (<i>Hemidactylium scutatum</i>)
NMAC	Red River Mudpuppy (<i>Necturus maculosus</i>)
NVIR	Central newt (<i>Notophthalmus viridescens</i>)
PGLU	Western slimy salamander (<i>Plethodon glutinosus</i>)
SINT	Western lesser siren (<i>Siren intermedia</i>)

REPTILES**Crocodylians**

AMIS	American alligator (<i>Alligator mississippiensis</i>)
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Turtles

AMUT	Midland smooth softshell (<i>Apalone mutica</i>)
ASPI	Spiny softshell (<i>Apalone spinifera</i>)
CPIC	Southern painted turtle (<i>Chrysemys picta</i>)
CSER	Snapping turtle (<i>Chelydra serpentina</i>)
DRET	Western chicken turtle (<i>Deirochelys reticularia</i>)
GGEO	Common map turtle (<i>Graptemys geographica</i>)

Turtles

GKOH	Mississippi map turtle (<i>G. kohnii</i>)
GPSE	Ouachita map turtle (<i>G. pseudogeographica</i>)
KSUB	Mississippi mud turtle (<i>Kinosternon subrubrum</i>)
MTEM	Alligator snapping turtle (<i>Macrolemys temminckii</i>)
PCON	River cooter (<i>Pseuemyss concinna</i>)
SCAR	Razorback musk turtle (<i>Sternotherus carinatus</i>)
SODO	Common musk turtle (<i>S. odoratus</i>)
TCAR	Three-toed box turtle (<i>Terrapene carolina</i>)
TORN	Ornate box turtle (<i>Terrapene ornata</i>)
TSCR	Red-eared slider (<i>Trachemys scripta</i>)

Lizards

ACAR	Green anole (<i>Anolis carolinensis</i>)
CSEX	Racerunner (<i>Cnemidophorus sexlineatus</i>)
EANT	Southern coal skink (<i>Eumeces anthracinus</i>)
EFAS	Five-lined skink (<i>E. fasciatus</i>)
ELAT	Broadhead skink (<i>E. laticeps</i>)
OATT	Western slender glass lizard (<i>Ophisaurus attenuatus</i>)
SLAT	Ground skink (<i>Scincella lateralis</i>)
SUND	Northern fence lizard (<i>Sceloporus undulatus</i>)

Snakes

ACON	Southern copperhead (<i>Agkistrodon contortrix</i>)
APIS	Western cottonmouth (<i>Agkistrodon piscivorus</i>)
CCOC	Northern scarlet snake (<i>Cemophora coccinea</i>)
CCON	Southern black racer (<i>Coluber constrictor</i>)
CHOR	Timber rattlesnake (<i>Crotalus horridus</i>)
CVER	Western worm snake (<i>Carphophis vermis</i>)
DPUN	Mississippi ringneck snake (<i>Diadophis punctatus</i>)
EGUT	Great plains rat snake/corn snake (<i>Elaphe guttata</i>)
EOBS	Black rat snake (<i>E. obsoleta</i>)
FABA	Western mud snake (<i>Farancia abacura</i>)
HPLA	Eastern hognose snake (<i>Heterodon platirhinos</i>)
LCAL	Prairie kingsnake (<i>Lampropeltis calligaster</i>)
LGET	Speckled kingsnake (<i>L. getula</i>)
LTRI	Red milk snake (<i>L. triangulum</i>)
MFLA	Eastern coachwhip (<i>Masticophis flagellum</i>)
MFUL	Texas coral snake (<i>Micrurus fulvius</i>)
NCYC	Mississippi green water snake (<i>Nerodia cyclopion</i>)
NERY	Yellowbelly water snake (<i>N. erythrogaster</i>)
NFAS	Broad-banded water snake (<i>N. fasciata</i>)
NRHO	Diamondback water snake (<i>N. rhombifer</i>)
NSIP	Midland water snake (<i>N. sipedon pleuralis</i>)
OAES	Rough green snake (<i>Opheodrys aestivus</i>)
RGRA	Graham's crayfish snake (<i>Regina grahamii</i>)
RRIG	Gulf crayfish snake (<i>R. rigida</i>)
SDEK	Midland brown snake (<i>Storeria dekayi</i>)
SMIL	Western pigmy rattlesnake (<i>Sistrurus miliarius</i>)
SOCC	Northern redbelly snake (<i>Storeria occipitomaculata</i>)
TGRA	Flathead snake (<i>Tantilla gracilis</i>)
TPRO	Western ribbon snake (<i>Thamnophis proximus</i>)
TSIR	Eastern garter snake (<i>T. sirtalis</i>)
VSTR	Rough earth snake (<i>Virginia striatula</i>)
VVAL	Western smooth earth snake (<i>V. valeriae</i>)

APPENDIX C.

Database records of species collections and observations.

Entry No./Date	Array	Trap No.	Species	Age	Status	Notes
5/30/2002						
1	OBS		EOBS	A	DOR	Found on road
2	OBS		OAES	A	DOR	Found on road
3	OBS		EOBS	A	A	Observation near hardwood restoration area
4	OBS		NERY	SA	A	In waterhole near array#2
5	OBS		ACRE	J	A	Hardwood restoration area-near array#2
6	OBS		AMIS	SA	A	Horseshoe lake
7	OBS		AMIS	A	A	Horseshoe lake
8	OBS		TSCR	A	A	Melanistic form of red-eared slider-horseshoe lake
9	OBS		TCAR	A	A	pine restoration area-near array#1
10	OBS		SLAT	SA	A	near array#1
11	OBS		SLAT	A	A	near array#1
12	OBS		SLAT	A	A	near array#1
13	OBS		EANT	SA	A	near array#1
5/31/2002						
14	OBS		PCON	A	A	on road near incinerator
15	1	3	BFOW	A	A	large adult Fowler's toad
16	1	1	RCLA	A	A	
17	1	1	RUTR	SA	A	
18	1	2	ACRE	A	A	1 dead southeastern shrew-1 alive w.f. mouse-pf1
19	OBS		TCAR	A	A	along fence btwn.production area & refuge woods
20	OBS		TCAR	A	A	along fence btwn.production area & refuge woods
21	OBS		TCAR	A	A	along fence btwn.production area & refuge woods
22	OBS		TCAR	A	A	along fence btwn.production area & refuge woods
23	OBS		TCAR	A	A	along fence btwn.production area & refuge woods
24	OBS		TCAR	A	A	along fence btwn.production area & refuge woods
25	OBS		TCAR	A	A	along fence btwn.production area & refuge woods
26	OBS		TCAR	A	A	along fence btwn.production area & refuge woods
27	OBS		TCAR	A	A	along fence btwn.production area & refuge woods
28	OBS		TCAR	A	A	along fence btwn.production area & refuge woods
29	OBS		TCAR	A	A	near array#2
30	2	1	RUTR	J	A	
31	2	pf1	GCAR	A	A	
32	2	2	GCAR	A	A	
33	OBS		BCHA	SA	A	traveling along silt fence at array#2
34	3	1	EFAS	A	A	observed running into trap at array#3 during cons.
35	OBS		AOPA	SA	A	found during construction of array#3
36	1	pf3	SLAT	J	A	
37	OBS		PTRI	A	A	observed along silt fence at array#1
38	2	3	CCON	A	A	48" - large adult racer
39	OBS		CCON	J	DOR	found on road near Warbritton gate
40	OBS		TSCR	A	A	crossing dirt road near arrays#2&3
41	OBS		APIS	A	A	large adult cottonmouth near array#4
42	OBS		APIS	A	A	smaller adult cottonmouth near array#4

Entry No./Date	Array	Trap No.	Species	Age	Status	Notes
6/3/2002						
43	1	3	SUND	A	A	3" female
44	1	pf1	BCHA	J	D	
45	1	pf1	SLAT	A	A	
46	1	pf1	SLAT	A	A	
47	1	pf2	SLAT	A	A	
48	1	pf2	BFOV	A	A	also one live bark scorpion in pf2
49	1	pf2	RCLA	J	A	
50	1	pf2	BCHA	A	D	
51	1	pf2	UnDA	NK	D	UnDA=unidentified dead anuran; NK=not known
52	1	pf2	UnDA	NK	D	
53	1	1	GCAR	A	A	
54	1	1	GCAR	A	A	
55	1	pf3	ACRE	A	D	
56	1	pf3	UnDA	NK	D	
57	1	pf3	RCLA	NK	D	
58	1	pf3	RUTR	A	D	
59	1	pf3	RCLA	SA	D	
60	1	pf3	GCAR	A	D	
61	1	pf3	GCAR	A	D	
62	1	pf3	RCLA	A	D	
63	1	pf3	UnDA	NK	D	
64	1	pf3	SLAT	A	D	
65	1	pf3	SLAT	A	A	only survivor of pf3 from the weekend
66	1	2	ACRE	NK	D	
67	1	2	EOBS	A	D	
68	1	2	RUTR	SA	A	
69	1	2	RUTR	A	A	
70	1	2	RUTR	A	D	
71	1	2	RUTR	A	D	
72	1	2	RUTR	A	D	
73	1	2	RUTR	A	D	
74	1	2	RUTR	A	D	
75	OBS		SLAT	A	A	adjacent to array#1
76	OBS		TCAR	SA	A	along fence btwn.production area & refuge woods
77	OBS		TCAR	SA	A	along fence btwn.production area & refuge woods
78	OBS		TCAR	A	A	along fence btwn.production area & refuge woods
79	OBS		TCAR	A	A	along fence btwn.production area & refuge woods
80	OBS		TCAR	A	A	along fence btwn.production area & refuge woods
81	OBS		TCAR	A	A	along fence btwn.production area & refuge woods
82	3	1	RUTR	SA	D	mortality from fire ants
83	3	1	RUTR	SA	D	mortality from fire ants
84	3	1	RUTR	A	D	mortality from fire ants
85	3	1	RUTR	A	D	mortality from fire ants
86	3	1	RUTR	SA	A	
87	3	1	RUTR	A	A	
88	3	1	RUTR	A	A	
89	3	1	RUTR	A	A	
90	3	pf1	GCAR	A	A	

Entry No./Date	Array	Trap No.	Species	Age	Status	Notes
6/3/2002 (cont.)						
91	OBS		RUTR	A	A	traveling along silt fence at array#3
92	OBS		RUTR	A	A	traveling along silt fence at array#3
93	3	pf2	RUTR	SA	A	
94	3	pf2	SLAT	A	A	
95	3	pf3	GCAR	A	A	also one short-tail shrew in pf3-alive
96	3	3	RUTR	A	A	
97	3	3	RUTR	A	A	
98	3	3	RUTR	A	D	
99	3	3	RUTR	A	D	
100	2	1	SLAT	A	A	
101	2	1	SLAT	A	A	
102	2	1	RUTR	A	A	
103	2	1	RUTR	NK	D	
104	OBS		SUND	A	A	large male running on the silt fence at array#2
105	2	pf2	GCAR	NK	D	evidence of large wolf spider(s) predation
106	2	pf2	BCHA	NK	D	evidence of large wolf spider(s) predation
107	2	2	RUTR	A	A	
108	OBS		BFOW	A	A	large specimen on silt fence at array#2
109	2	pf3	AOPA	SA	A	first salamander caught by trap of the project
110	OBS		BFOW	SA	A	young specimen along silt fence at array#2
111	2	3	SLAT	A	A	
112	2	3	RUTR	NK	D	
113	4	pf2	GCAR	SA	A	
114	4	pf2	GCAR	A	A	also two dead southeastern shrews in pf2-array#4
115	OBS		SUND	A	A	resting on top of trap2-array#4
116	4	pf3	GCAR	A	A	also one dead southeastern shrew in pf3-array#4
117	OBS		TPRO	A	A	in waterholes along logging road to Tulley Lake
118	OBS		TPRO	SA	A	in waterholes along logging road to Tulley Lake
119	OBS		TPRO	A	A	in waterholes along logging road to Tulley Lake
120	OBS		TPRO	A	A	in waterholes along logging road to Tulley Lake
121	OBS		RCAT	SA	A	in waterholes along logging road to Tulley Lake
122	OBS		RCAT	SA	A	in waterholes along logging road to Tulley Lake
123	OBS		RCAT	SA	A	in waterholes along logging road to Tulley Lake
124	OBS		RCAT	SA	A	in waterholes along logging road to Tulley Lake
125	OBS		RCAT	SA	A	in waterholes along logging road to Tulley Lake
126	OBS		RCAT	SA	A	in waterholes along logging road to Tulley Lake
127	OBS		RCAT	SA	A	in waterholes along logging road to Tulley Lake
128	OBS		RCAT	SA	A	in waterholes along logging road to Tulley Lake
129	OBS		RCAT	SA	A	in waterholes along logging road to Tulley Lake
130	OBS		RCAT	SA	A	in waterholes along logging road to Tulley Lake
131	OBS		NERY	SA	A	in waterholes along logging road to Tulley Lake
6/4/2002						
132	OBS		TCAR	A	A	along McCoy Road
133	OBS		TCAR	A	A	along McCoy Road
134	OBS		TCAR	SA	A	along McCoy Road
135	1	pf3	BFOW	A	A	
136	1	3	RUTR	SA	A	
137	OBS		EFAS	SA	A	along silt fence of array#1

Entry No./Date	Array	Trap No.	Species	Age	Status	Notes
6/4/2002 (cont.)						
138	OBS		SUND	A	A	along silt fence of array#1
139	1	pf1	GCAR	A	A	
140	1	pf1	GCAR	A	A	
141	1	pf1	RCLA	SA	A	young bronze frog
142	1	pf1	SLAT	A	A	
143	1	1	RUTR	A	A	
144	1	1	RUTR	SA	A	
145	1	pf2	GCAR	SA	A	individual alive but stressed-put in shady wet spot
146	1	2	RUTR	SA	A	
147	1	2	RUTR	SA	A	
148	1	2	RUTR	SA	A	all young sub-adult so. Leopard frogs in this trap
149	OBS		ACRE	A	A	cricket frog on silt fence at array#1
150	OBS		EOBS	A	A	very large(~5')-on perimeter road by refuge ponds
151	OBS		TSCR	A	A	adult female egg-laying in sand on perimeter road
152	3	3	RUTR	A	A	
153	3	3	RUTR	NK	D	mortality from very large wolf spider in trap
154	OBS		RCLA	A	A	along silt fence at array#3
155	OBS		SUND	SA	A	on silt fence at array#3
156	3	3	RUTR	SA	A	
157	2	1	VSTR	A	A	8"-long rough earth snake
158	2	2	CCON	A	D	no explanation for mortality
159	2	2	GCAR	A	A	
160	2	2	RUTR	A	A	
161	2	2	RUTR	SA	A	
162	2	2	RUTR	A	A	
163	2	2	RUTR	A	A	
164	OBS		TCAR	A	A	along fence btwn. Production area & refuge woods
165	4	2	SUND	A	A	
166	OBS		CSEX	A	A	adult female on horseshoe lake peninsula
167	OBS		CSEX	A	A	adult male on horseshoe lake peninsula
168	OBS		CSEX	SA	A	younger specimen on horseshoe lake peninsula
169	OBS		AMIS	A	A	large adult in "bubbly fountain pond"
170	OBS		OAES	A	A	on logging road adjacent to Tulley Lake
171	OBS		TSCR	A	A	on Wise Road to Triplett's Bluff
172	OBS		CCON	A	A	adjacent to Nilo pond
173	OBS		RUTR	A	A	large brightly colored adult adjacent to Nilo pond
174	OBS		CSEX	A	A	adjacent to water well disturbance near Nilo pond
175	OBS		RCLA	A	A	along creek at fireline on Triplett's bluff
176	OBS		RCLA	A	A	along creek at fireline on Triplett's bluff
177	OBS		RCLA	A	A	along creek at fireline on Triplett's bluff
178	OBS		RCLA	A	A	along creek at fireline on Triplett's bluff
179	OBS		RCLA	A	A	along creek at fireline on Triplett's bluff
180	OBS		RCLA	A	A	along creek at fireline on Triplett's bluff
181	OBS		RCLA	A	A	along creek at fireline on Triplett's bluff
182	OBS		RUTR	SA	A	along creek at fireline on Triplett's bluff
183	OBS		RUTR	A	A	along creek at fireline on Triplett's bluff
184	OBS		RUTR	SA	A	along creek at fireline on Triplett's bluff
185	OBS		RUTR	SA	A	along creek at fireline on Triplett's bluff

Entry No./Date	Array	Trap No.	Species	Age	Status	Notes
6/4/2002 (cont.)						
186	OBS		RUTR	A	A	along creek at fireline on Triplett's bluff
187	OBS		RUTR	A	A	along creek at fireline on Triplett's bluff
188	OBS		PTRI	A	A	along creek at fireline on Triplett's bluff
189	OBS		PTRI	A	A	along creek at fireline on Triplett's bluff
190	OBS		PTRI	A	A	along creek at fireline on Triplett's bluff
191	OBS		ACRE	A	A	along creek at fireline on Triplett's bluff
6/6/2002						
192	1	3	LGET	A	A	3' speckled kingsnake
193	1	3	RUTR	A	A	
194	1	3	RUTR	SA	D	predation evident-viscera removed
195	1	3	RUTR	A	D	predation evident-viscera removed
196	1	3	RCLA	A	A	
197	1	pf3	BFOW	A	A	
198	1	1	GCAR	A	A	
199	1	1	GCAR	A	A	
200	1	2	RUTR	A	D	partially eaten-possibly from live harvest mouse
201	1	2	AMAC	A	A	first salamander caught in funnel trap of project
202	OBS		TCAR	A	A	mating along production area fence
203	OBS		TCAR	A	A	mating along production area fence
204	OBS		TCAR	A	D	recently (<2days) predated
205	3	1	RUTR	A	A	
206	3	1	RUTR	A	A	
207	3	1	RUTR	SA	A	
208	3	1	RUTR	A	A	
209	3	1	RUTR	A	A	
210	3	1	RUTR	A	A	
211	3	1	RUTR	SA	A	
212	3	1	RUTR	SA	A	
213	3	1	RUTR	A	A	
214	3	1	RUTR	A	A	
215	3	1	RUTR	A	A	
216	3	1	RUTR	SA	A	
217	3	1	RUTR	NK	D	mortality from very large wolf spider in trap
218	3	pf1	RUTR	NK	D	half-consumed-possibly from live s.t. shrew
219	OBS		RUTR	A	A	on silt fence at array#3
220	3	3	RUTR	A	A	
221	3	2	AOPA	A	A	
222	3	2	AOPA	A	A	
223	3	2	AMAC	J	A	
224	3	2	AMAC	A	A	
225	2	1	RUTR	A	A	
226	2	1	AMAC	A	A	
227	2	1	EFAS	SA	A	young five-lined skink still with bright blue tail
228	2	1	RUTR	A	A	
229	2	2	BFOW	A	A	
230	2	2	RUTR	A	A	
231	2	2	RUTR	A	A	
232	2	2	RUTR	A	A	

Entry No./Date	Array	Trap No.	Species	Age	Status	Notes
6/6/2002 (cont.)						
233	2	2	RUTR	A	A	
234	2	2	RUTR	A	A	
235	2	2	RUTR	A	A	
236	2	2	RUTR	A	A	
237	2	2	RUTR	A	A	
238	2	2	RUTR	A	A	
239	2	2	RUTR	A	A	
240	2	2	RUTR	A	A	
241	2	2	RUTR	A	D	
242	2	2	RUTR	A	D	
243	2	2	RUTR	A	D	
244	2	2	RUTR	J	A	
245	2	2	AMAC	SA	A	
246	4	2	VSTR	SA	A	young rough earth snake
247	4	pf3	GCAR	A	A	
248	4	3	SUND	A	A	fence lizard
6/7/2002						
249	1	pf1	SLAT	A	A	lost tail on release
250	1	pf1	GCAR	SA	A	
251	1	pf3	GCAR	A	A	
252	OBS		TCAR	A	A	production area fenceline
253	OBS		BCHA	A	D	found on road dead-near arrays 2/3
254	3	1	RUTR	A	A	
255	3	1	RUTR	A	A	
256	3	1	RUTR	A	A	
257	3	pf1	RCLA	A	A	
258	3	2	RUTR	A	D	predated by shrew in trap
259	3	2	RUTR	A	D	predated by shrew in trap
260	3	2	GCAR	A	A	
261	3	3	RUTR	A	A	
262	OBS		RUTR	A	A	
263	2	pf2	RUTR	A	A	
264	2	pf2	RUTR	A	A	
265	2	2	RUTR	A	A	
266	2	2	RUTR	A	A	
267	2	2	RUTR	A	A	
268	OBS		SUND	A	A	on silt fence at array#2
269	OBS		EFAS	A	A	on silt fence at array#2
270	2	3	RUTR	A	A	
271	OBS		SLAT	A	A	on trail between arrays 2 and 3
272	OBS		SLAT	A	A	on trail between arrays 2 and 3
273	4	2	NERY	J	A	first watersnake caught by trap of study
274	OBS		TSCR	A	A	in first of 2 drainage ponds near horseshoe pond
7/10/2002						
275	OBS		SUND	A	A	near array#1 on log
276	1	pf2	SLAT	A	A	
277	OBS		BCHA	J	A	very young
278	OBS		BCHA	A	D	near array#3-no evidence of predation
279	2	3	RCLA	A	A	

Entry No./Date	Array	Trap No.	Species	Age	Status	Notes
7/10/2002 (cont.)						
280	2	2	ACRE	A	A	
7/12/2002						
281	3	3	RUTR	A	D	killed by fire ants
282	3	pf3	EFAS	A	A	
283	3	pf3	EFAS	SA	A	
284	2	1	RUTR	SA	D	
285	2	3	RUTR	A	A	
286	2	3	BCHA	A	D	evidence of predation
287	2	3	RUTR	SA	D	
288	5	2	TPRO	A	A	western ribbon snake
289	4	2	LCAL	A	A	prairie kingsnake
290	6	pf1	EFAS	SA	A	
7/13/2002						
291	1	pf3	GCAR	A	A	
292	1	2	AOPA	A	A	
293	1	2	RUTR	A	A	
294	1	2	RUTR	SA	A	
295	1	2	PCRU	J	A	young spring peeper
296	1	pf1	GCAR	A	A	
297	1	pf1	BCHA	J	A	
298	1	3	BCHA	J	A	
299	1	3	BCHA	J	A	
300	1	3	BCHA	J	A	
301	1	3	GCAR	A	A	
302	1	3	GCAR	A	A	
303	1	3	RUTR	A	A	
304	1	3	GCAR	A	A	
305	1	3	BFOW	J	A	
306	1	3	GCAR	SA	A	
307	1	3	GCAR	J	A	
308	1	3	RUTR	A	A	
309	1	3	GCAR	A	A	
310	1	3	ACRE	J	A	
311	1	pf2	BFOW	J	A	
312	1	pf2	BFOW	J	A	
313	1	pf2	BFOW	J	A	
314	1	pf2	BFOW	J	A	
315	1	pf2	BFOW	J	A	
316	1	pf2	BFOW	J	A	
317	1	pf2	BFOW	J	A	
318	1	1	RUTR	A	A	
319	1	1	GCAR	A	A	
320	1	1	GCAR	A	A	
321	1	1	GCAR	A	A	
322	1	1	RUTR	A	A	
323	1	1	BFOW	A	A	
324	1	1	BFOW	A	A	
325	3	3	RUTR	A	A	

Entry No./Date	Array	Trap No.	Species	Age	Status	Notes
7/13/2002 (cont.)						
326	3	3	RUTR	A	A	
327	3	1	GCAR	SA	A	
328	3	2	RUTR	A	A	
329	3	pf3	BCHA	SA	A	
330	3	pf3	EFAS	J	A	
331	3	1	BFOW	J	A	
332	3	1	BFOW	J	A	
333	3	1	BFOW	J	A	
334	3	1	BFOW	J	A	
335	2	1	CCON	A	A	
336	2	1	CCON	A	A	
337	2	1	BFOW	J	A	
338	2	pf1	GCAR	SA	A	
339	2	pf1	GCAR	SA	A	
340	2	2	GCAR	J	A	
341	2	2	RUTR	A	A	
342	2	2	RUTR	A	A	
343	2	2	GCAR	A	A	
344	2	2	RUTR	SA	A	
345	2	2	RUTR	SA	A	
346	2	2	BFOW	J	A	
347	4	2	AOPA	A	A	
348	OBS		SUND	A	A	on trap at array#5
349	5	pf2	ATAL	A	A	**mole salamander-outside of listed range
350	6	3	TPRO	SA	A	
351	OBS		RUTR	A	A	by nilo pond
352	OBS		RUTR	A	A	by nilo pond
353	OBS		CSEX	A	A	by nilo pond
354	OBS		TPRO	SA	A	by nilo pond
7/17/2002						
355	1	3	SLAT	A	A	
356	3	3	GCAR	A	A	
357	3	3	RUTR	A	A	
358	OBS		TCAR	A	A	inside production area fenceline
7/18/2002						
359	1	2	PCRU	A	A	
360	1	pf1	GCAR	A	A	
361	1	3	RUTR	A	A	
362	1	3	BFOW	J	A	
363	1	3	RUTR	A	A	
364	1	3	BFOW	J	A	
365	1	3	RUTR	A	A	
366	1	3	ACRE	A	A	
367	1	3	ACRE	A	A	
368	1	1	GCAR	SA	A	
369	1	1	RUTR	A	A	
370	1	1	ACRE	J	A	
371	OBS		TPRO	A	A	along fenceline at array#3
372	3	2	RUTR	A	A	

Entry No./Date	Array	Trap No.	Species	Age	Status	Notes
7/18/2002 (cont.)						
373	2	1	RUTR	A	A	
374	2	3	RUTR	A	A	
375	2	3	RUTR	A	A	
376	2	2	RUTR	A	A	
377	2	2	RUTR	A	A	
378	OBS		TCAR	A	A	along production area fenceline
379	OBS		TCAR	A	A	along production area fenceline
380	OBS		AMIS	J	A	in Tulley Creek near horseshoe pond turnoff
381	OBS		TSCR	A	A	in Tulley Creek near horseshoe pond turnoff
382	5	2	ACRE	J	A	
383	5	2	ACRE	J	A	
384	4	1	ACRE	J	A	
385	OBS		RUTR	A	A	
386	OBS		TSCR	A	A	on road to array#6
387	6	1	GCAR	A	A	

Array = array number species was collected or OBS = opportunistic observation

Trap No. = funnel trap (1-3) or pitfall trap (pf 1-3) that species was captured

Species = four-letter code for species captured/observed (Appendix B)

Age = estimated age of individual captured/observed (A = adult, J = juvenile, SA = sub-adult,

NK = age not known)

Status = condition of individual (A = alive, D = dead, DOR = dead on road)

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****This list consists of publications that assisted the principal investigator in varying degrees, in respect to positive species identification, range maps, and life history information.**

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THE NATURE CONSERVANCY **FIRE SUMMARY REPORT AND POST BURN EVALUATION**

Site: Pine Bluff Arsenal; 14,944 acres.

Unit: Bomb Storage units A-D, 1, 5, and 9; Seven units, 77 acres.

Date burned: 28 Feb. and 04 March 2002

Date evaluated: 11 March 2002

Report date: 14 May 2002.

Reported by: Mike Melnechuk

Fire Weather Forecast:

Date:	28 Feb. 2002	04 March 2002
Time:	0930	1215
Humidity (low):	32%	30%
Temperature (high):	45°F	46°F
20' Windspeed:	15 mph	10 mph
Wind direction:	west	south/SW
Sky:	clear	clear
KBDI:		
Comments:	Could not get an accurate RH until the temp. rose in the afternoon (4 Mar.).	

Onsite Weather:

Time:	(2-28-02)1500	(3-4-02)1130	1215	1250
Location:	west line	SW corner	west line	NE corner
By:	Erica Taecker	ET	ET	ET
Dry bulb:	41°F	36°	40°	42°
Wet bulb:	32°F	<30°	31°	34°
Humidity:	32%	38%	30%	40%
Wind speed:	0-5 mph	0-5	0-5	0-5
Wind direction:	west	SW	SW	SW
Sky:	clear	clear	clear	clear

Crew - Unit D (2-28-02)

On-crew: Doug Sprouse - fire leader (water and rake) with Justin Zarzeczny - igniter (drip torch), Nathan White - 2nd water (water and rake), and Erica Taecker - drag (water and rake).

Off-crew: Mike Melnechuk - crew boss (water and rake) with Kelly Drey - igniter (drip torch), and Mickey Matthews - drag (ATV with water, rake, and flapper).

Ignition begun:	1530; at SE corner
Perimeter rung:	1550; at NW corner
Interior ignition completed:	1630.
Interior burnout:	1900.

Fire narrative:

The firelines were all roads. Power-poles and an electrical box were raked around to 5' before the burn. Twenty minutes of crew time was spent preparing the unit. All lines were adjacent to FM2 and FM9. The firelines were all ATV and pumper accessible.

Water was obtained from the PBA fire department the morning of the burn. Due to the small size of the unit, and the accessibility of the lines, no water or DT fuel jugs were staged on the lines. Reserve DT fuel was staged in the pumpers and on ATV's. Both pumpers were staged with flappers, pulaski, extra waterpacks, drip torch fuel, and fire rakes prior to the burn. Both ATV's were staged with flappers, waterpacks, and pulaskis and used by drag and holding personnel for patrol.

Sprouse obtained a weather forecast from the National Weather Service and made official notifications. The crew prepped the unit. Taecker took onsite weather. A crew briefing was held at 1520 and a test fire was lit at the SE corner at 1530. After five minutes of test fire, with the wind steady and smoke lifting well, the burn was initiated.

A ring fire technique was utilized. Two igniters started at the southeast corner, with Zarzeczny following the east line, and Drey igniting the south line, establishing blackline. Once the crews had enough blackline on the east and south lines, they turned the corners and began to light headfire. The crews met at the NW corner, and the unit was rung at 1550, in twenty minutes. Melnechuk assumed control of the lines and Sprouse and Zarzeczny began interior ignition of logging slash. White also went interior to burn-out remaining patches of fuel. Interior ignition was complete at 1630, and downed woody debris continued to burn into the night. The crew de-staged the unit, a debriefing was given, and the crew departed at 1730, with some slash piles still burning and producing smoke. The unit was deemed secure, and a hard frost that evening extinguished all smokers. The unit was cold-out the next day.

No holding problems were encountered on this burn. Smoke was sometimes heavy along the east line, but the quick ring-fire and immediate interior ignition alleviated this

problem. Backfire flame lengths were 0.5-1.0 feet. Flanking fire flame lengths were 1.5-2.5 feet. Headfire flame lengths were generally around 2-3 feet, torching to 10 feet in areas with downed woody debris.

Crew – Units A, B, C, 1, 5, and 9 (3-4-02)

On-crew: Doug Sprouse – fire leader (water and flapper) with Mickey Matthews – igniter (drip torch), Justin Zarzeczny – 2nd water (water and flapper), and Kelly Drey – drag (ATV with water, rake, flapper, and DT fuel).

Off-crew: Mike Melnechuk – crew boss (water and rake) with Erica Taecker – igniter (drip torch), and Nathan White – drag (GMC pumper with 200 gallons of water, rake, pulaski, flapper, and DT fuel).

Ignition begun:	1300; at NE corner
Perimeter rung:	1335; at SW corner
Interior ignition completed:	1500.
Interior burnout:	2100.

Fire Narrative:

The firelines were all 20'-wide gravel and paved roads. Power-poles, electrical wiring around the bomb storage buildings, and equipment were raked around to 5' the day of the burn. The grass around the buildings was mown by base personnel to 3" prior to the burns. All lines were adjacent to FM2, FM3, and FM9. The firelines were all ATV and pumper accessible.

The crew obtained water at the base fire department the morning of the burn. Due to the accessibility of the lines, no reserve water or drip torch fuel jugs were staged on the lines. Reserve DT fuel was staged on the pumpers and ATV's. Both pumpers were staged with flappers, pulaski, extra waterpacks, drip torch fuel, and fire rakes prior to the burn. Both ATV's were staged with flappers, waterpacks, and pulaskis and used by drag and holding personnel for patrol.

Sprouse obtained a weather forecast from the National Weather Service and made official notifications. The crew prepped the unit. Taecker took onsite weather. A crew briefing was held at 1255 and a test fire was lit at the NE corner at 1300. After five minutes of test fire, with the wind steady and smoke lifting well, the burn was initiated.

Due to the contiguous nature of the units, they were all burned together, utilizing interior roads to speed burn-out. All the bomb storage buildings were burned-out around to 15' before headfire was sent in their direction. Igniters started at the NE corner and moved in opposite directions, lighting backfire/flanking fire on the north and east lines, and mainly headfire on the south and west lines. The two crews met at the SW corner at 1335, and the units were rung in 35 minutes. Interior ignition began immediately after, with Melnechuk, Taecker, and Matthews igniting any unburned fuels and debris piles, while

the rest of the crew patrolled the firelines. Interior ignition lasted for about an hour and a half, with many large slash piles becoming engaged. Interior ignition was completed at 1500, with woody debris burning into the night. The lines were deemed secure by Sprouse and Melnechuk, and the crew de-staged the equipment, a de-briefing was held, and the crew left the site. A hard frost extinguished most remaining smokers that evening, there was very little still burning the following day.

No holding problems were encountered on this burn. Smoke was sometimes heavy along the east line, but the quick ring-fire and immediate interior ignition alleviated this problem. Backfire flame lengths were 0.5-1.0 feet. Flanking fire flame lengths were 1.5-2.5 feet. Headfire flame lengths were generally around 2-4 feet, torching to 15 feet in areas with downed woody debris.

IMMEDIATE POST BURN EFFECTS

IMMEDIATE POST BURN EFFECTS- PBA Bomb Storage Units

Unit A

Overall unit	Pine savanna/slash
Unit coverage	80%
Burn severity organic substrate	1.2 (lightly burned)
Burn severity understory	2.3 (lightly burned)
Char height	1.0 (less than 10')
Char degree	1.0 (light)
Scorch percent	1 (less than 25% of live crown)
Scorch height	1 (less than 10')

By natural community	pine savanna/slash
Fuel model	2
Coverage	80 %
Organic substrate	1.2 (light)
Understory	2.3 (light-moderate)
Char height	1.0 (less than 5')
Char degree	1.0 (light)
Scorch percent	1.0 (less than 25%)
Scorch height	1.0 (less than 10')

ECOLOGICAL OBJECTIVES

1. Unit coverage 65-85%
2. Substrate burn severity = 1.0 – 3.0. Overall substrate burn severity class = 1.2 (scorched). Based on the patchiness of the grassy substrate, the burn severity was fairly mild. Plant structures were intact above the ground.
3. Understory burn severity class = 1.0 – 3.0. Overall understory burn severity class = 2.3 (lightly burned) and ranged from 2 – 3. Grasses in thicker patches burned down to base of plant leaving green structures recognizable. Some more sparsely located grasses did not burn at all.

4. Overstory char height = 1.0 – 2.0. Overall overstory char height = 1.0 (less than 5'). Char height seldom exceeded 5' except on occasional pine near small slash piles, and was usually less than 1' throughout the unit. This level of char will only impact the smaller trees and shrubs within the unit.
5. Overstory char degree = 0.5-1.5. Overall overstory char degree = 1.0 (light). There was little to no reduction in bark thickness in this unit, except where slash piles burned.
6. Overstory scorch percent class = 0.5– 2.0. Overall overstory scorch percent = 1.0 (less than 25% of live crown). The widely-spaced overstory trees in the unit are unlikely to be scorched due to their height.
7. Overstory scorch height class = 0.5 – 1.5. Overall overstory scorch height class = 1.0 (less than 25'). Due to the lack of a midstory, scorch height was judged to be in the low range.

IMMEDIATE POST BURN EFFECTS- PBA Bomb Storage Units

Unit B

Overall unit	Pine savanna/slash
Unit coverage	80%
Burn severity organic substrate	2.3 (lightly burned)
Burn severity understory	2.7 (moderately burned)
Char height	1.0 (less than 5')
Char degree	1.1 (light)
Scorch percent	0.9 (less than 25% of live crown)
Scorch height	1.0 (less than 10')

By natural community	pine savanna/slash
Fuel model	2
Coverage	80 %
Organic substrate	2.3 (light)
Understory	2.7 (light-moderate)
Char height	1.0 (less than 5')
Char degree	1.1 (light)
Scorch percent	0.9 (less than 25%)
Scorch height	1.0 (less than 10')

ECOLOGICAL OBJECTIVES

8. Unit coverage 65-85%
9. Substrate burn severity = 1.0 – 3.0. Overall substrate burn severity class = 2.3 (lightly burned). Based on the patchiness of the grassy substrate, the burn severity was moderate. Plant structures were intact above the ground.
10. Understory burn severity class = 1.0 – 3.0. Overall understory burn severity class = 2.7 (moderately burned) and ranged from 0-4. Grasses in thicker patches burned down to base of plant leaving green structures recognizable. Some more sparsely located grasses did not burn at all, while patches near slash piles burned down to mineral soil.
11. Overstory char height = 1.0 – 2.0. Overall overstory char height = 1.0 (less than 5'). Char height seldom exceeded 5' except on occasional pine near small slash piles, and was usually less than 1' throughout the unit. This level of char will only impact the smaller trees and shrubs within the unit.

12. Overstory char degree = 0.5-1.5. Overall overstory char degree = 1.1 (light). There was little to no reduction in bark thickness in this unit, except where slash piles burned.
13. Overstory scorch percent class = 0.5-2.0. Overall overstory scorch percent = 0.9 (less than 25% of live crown). The widely-spaced overstory trees in the unit are unlikely to be scorched due to their height and the patchiness of understory fuels.
14. Overstory scorch height class = 0.5 - 1.5. Overall overstory scorch height class = 1.0 (less than 25'). Due to the lack of a midstory, scorch height was judged to be in the low range.

IMMEDIATE POST BURN EFFECTS- PBA Bomb Storage Units Unit C

Overall unit	Pine savanna/slash
Unit coverage	90%
Burn severity organic substrate	1.9 (lightly burned)
Burn severity understory	2.1 (moderately burned)
Char height	1.9 (less than 10')
Char degree	1.1 (light)
Scorch percent	1.0 (less than 25% of live crown)
Scorch height	1.8 (less than 20')

By natural community	pine savanna/slash
Fuel model	2
Coverage	90 %
Organic substrate	1.9 (light)
Understory	2.1 (light-moderate)
Char height	1.9 (less than 10')
Char degree	1.1 (light)
Scorch percent	1.0 (less than 25%)
Scorch height	1.8 (less than 20')

ECOLOGICAL OBJECTIVES

15. Unit coverage 65-85%
16. Substrate burn severity = 1.0 - 3.0. Overall substrate burn severity class = 1.9 (lightly burned). Based on the patchiness of the grassy substrate, the burn severity was moderate. Plant structures were intact above the ground.
17. Understory burn severity class = 1.0 - 3.0. Overall understory burn severity class = 2.1 (moderately burned) and ranged from 0-3. Grasses in thicker patches burned down to base of plant leaving green structures recognizable. Some more sparsely located grasses did not burn at all, while patches near slash piles burned down to mineral soil.
18. Overstory char height = 1.0 - 2.0. Overall overstory char height = 1.0 (less than 5'). Char height seldom exceeded 5' except on occasional pine near small slash piles, and was usually less than 1' throughout the unit. This level of char will only impact the smaller trees and shrubs within the unit.

19. Overstory char degree = 0.5-1.5. Overall overstory char degree = 1.9 (medium). There was medium reduction in bark thickness in this unit where slash piles burned.
20. Overstory scorch percent class = 0.5- 2.0. Overall overstory scorch percent = 1.9 (less than 25% of live crown). The widely-spaced overstory trees in the unit are unlikely to be scorched due to their height and the patchiness of understory fuels.
21. Overstory scorch height class = 0.5 - 1.5. Overall overstory scorch height class = 1.8 (less than 25'). Due to the lack of a midstory, scorch height was judged to be in the low range.

IMMEDIATE POST BURN EFFECTS- PBA Bomb Storage Units
Unit D

Overall unit	Pine savanna/slash
Unit coverage	95%
Burn severity organic substrate	2.0 (lightly burned)
Burn severity understory	2.5 (moderately burned)
Char height	1.0 (less than 5')
Char degree	1.3 (light)
Scorch percent	1.0 (less than 25% of live crown)
Scorch height	1.0 (less than 10')

By natural community	pine savanna/slash
Fuel model	2
Coverage	80 %
Organic substrate	2.0 (light)
Understory	2.5 (light-moderate)
Char height	1.0 (less than 5')
Char degree	1.3 (light)
Scorch percent	1.0 (less than 25%)
Scorch height	1.0 (less than 10')

ECOLOGICAL OBJECTIVES

22. Unit coverage 65-85%
23. Substrate burn severity = 1.0 - 3.0. Overall substrate burn severity class = 2.0 (lightly burned). Based on the patchiness of the grassy substrate, the burn severity was moderate. Plant structures were intact above the ground.
24. Understory burn severity class = 1.0 - 3.0. Overall understory burn severity class = 2.5 (moderately burned) and ranged from 1-3. Grasses in thicker patches burned down to base of plant leaving green structures recognizable. Some more sparsely located grasses did not burn at all, while patches near slash piles burned down to mineral soil.

25. Overstory char height = 1.0 – 2.0. Overall overstory char height = 1.0 (less than 5'). Char height seldom exceeded 5' except on occasional pines near small slash piles, and was usually less than 1' throughout the unit. This level of char will only impact the smaller trees and shrubs within the unit.
26. Overstory char degree = 0.5-1.5. Overall overstory char degree = 1.3 (light). There was little to no reduction in bark thickness in this unit, except where slash piles burned.
27. Overstory scorch percent class = 0.5– 2.0. Overall overstory scorch percent = 1.0 (less than 25% of live crown). The widely-spaced overstory trees in the unit are unlikely to be scorched due to their height and the patchiness of understory fuels.
28. Overstory scorch height class = 0.5 – 1.5. Overall overstory scorch height class = 1.0 (less than 25'). Due to the lack of a midstory, scorch height was judged to be in the low range.

IMMEDIATE POST BURN EFFECTS- PBA Bomb Storage Units
Unit 1

Overall unit	Pine savanna/slash
Unit coverage	80%
Burn severity organic substrate	2.0 (lightly burned)
Burn severity understory	2.5 (moderately burned)
Char height	1.0 (less than 5')
Char degree	1.3 (light)
Scorch percent	1.0 (less than 25% of live crown)
Scorch height	1.0 (less than 10')

By natural community	pine savanna/slash
Fuel model	2
Coverage	80 %
Organic substrate	2.0 (light)
Understory	2.5 (light-moderate)
Char height	1.0 (less than 5')
Char degree	1.3 (light)
Scorch percent	1.0 (less than 25%)
Scorch height	1.0 (less than 10')

ECOLOGICAL OBJECTIVES

29. Unit coverage 65-85%
30. Substrate burn severity = 1.0 – 3.0. Overall substrate burn severity class = 2.0 (lightly burned). Based on the patchiness of the grassy substrate, the burn severity was moderate. Plant structures were intact above the ground.
31. Understory burn severity class = 1.0 – 3.0. Overall understory burn severity class = 2.5 (moderately burned) and ranged from 1-3. Grasses in thicker patches burned down to base of plant leaving green structures recognizable. Some more sparsely located grasses did not burn at all, while patches near slash piles burned down to mineral soil.
32. Overstory char height = 1.0 – 2.0. Overall overstory char height = 1.0 (less than 5'). Char height seldom exceeded 5' except on occasional pines near small slash piles, and was usually less than 1' throughout the unit. This level of char will only impact the smaller trees and shrubs within the unit.

33. Overstory char degree = 0.5-1.5. Overall overstory char degree = 1.3 (light). There was little to no reduction in bark thickness in this unit, except where slash piles burned.
34. Overstory scorch percent class = 0.5- 2.0. Overall overstory scorch percent = 1.0 (less than 25% of live crown). The widely-spaced overstory trees in the unit are unlikely to be scorched due to their height and the patchiness of understory fuels.
35. Overstory scorch height class = 0.5 - 1.5. Overall overstory scorch height class = 1.0 (less than 25'). Due to the lack of a midstory, scorch height was judged to be in the low range.

IMMEDIATE POST BURN EFFECTS PBA Bomb Storage Units
Units 5 and 9

Overall unit	pine savannah/mown grasss
Unit coverage	75-80%
Burn severity organic substrate	1.3 (light)
Burn severity understory	1.9 (light to moderate)
Char height	2.3 (5'-20')
Char degree	1.8 (light to moderate)
Scorch percent	1.1 (less than 25% of live crown)
Scorch height	1.9 (10'-20')

By natural community	Pine savannah/slash	Mown grass
Fuel model	2	1
Coverage	85-90%	50%
Organic substrate	1.7 (light)	1 (light)
Understory	2.7 (light to moderate)	1 (light)
Char height	2.3 (5'-20')	
Char degree	1.8 (light to moderate)	
Scorch percent	1.1 (less than 25%)	
Scorch height	1.9 (10'-20')	

ECOLOGICAL OBJECTIVES

36. Unit coverage 65-85%. The unit was 75-80% burned. Areas that did not burn include wet areas and portions of the mown right-of-ways by the bomb storage units and power line.
37. Substrate burn severity = 1.0 - 3.0. Overall substrate burn severity class = 1.3 (lightly burned) and ranged from 1.0-3.0. The burn severity in the substrate was light, however, some areas around scattered slash piles burned down to mineral soil. In most of the unit, plant structures were intact above the ground.
38. Understory burn severity class = 1.0 - 3.0. Overall understory burn severity class = 1.9 (lightly to moderately burned) and ranged from 1.0 - 4.0. Grasses in thicker patches burned down to base of plant leaving green structures recognizable; a few more sparsely located grasses did not burn at all. In many areas larger stems of other herbaceous species were also consumed.
39. Overstory char height = 0.5-1.5. Overall overstory char height = 2.3 (5'-20'). Pine trees near slash piles were likely to be charred, char height averaged around 15'.
40. Overstory char degree = 0.5-1.5. Overall overstory char degree = 1.8 (light to moderate) and ranged from 1.0-2.0. There was light to moderate reduction in bark thickness in this unit, due to the occasional

slash pile near which certain trees burned. Most of the trees that were charred were large enough to be unaffected.

41. Overstory scorch percent class = 0.5-2.0. Overall overstory scorch percent = 1.1 (less than 25% of live crown) and ranged from 1.0-2.0 (less than 25% to 50%). The widely-spaced overstory trees in the unit are unlikely to be scorched due to their height. A few shorter trees near slash piles were scorched up to 50%
42. Overstory scorch height class = 0.5-1.5. Overall overstory scorch height class = 1.9 (10'-20') and ranged 1.0-2.0 (less than 10' to 25'). Pine trees near slash piles were more likely to be scorched; scorch height was generally between 10' and 15'.

THE NATURE CONSERVANCY **FIRE SUMMARY REPORT AND POST BURN EVALUATION**

Site: Pine Bluff Arsenal; 14,944 acres.
Unit: Tulley Lake unit; 15 acres.

Date burned: 28 February 2002
Date evaluated: 11 March 2002
Report date: 14 May 2002.
Reported by: Mike Melnechuk

Fire Weather Forecast:

Date:	28 Feb. 2002
Time:	0930
Humidity (low):	32%
Temperature (high):	45°F
20' Windspeed:	15 mph
Wind direction:	west
Sky:	clear
KBDI:	
Comments:	Westerly winds helped by the open expanse of Tulley Lake

Onsite Weather:

Time:	1100	1145	1330
Location:	staging	staging	staging
By:	Erica Taecker	ET	ET
Dry bulb:	30°F	37°	39°
Wet bulb:	NA°F	30°	31°
Humidity:	NA%	40%	35%
Wind speed:	0-5 mph	5	0-5
Wind direction:	west	west	west
Sky:	clear	clear	clear

Crew

On-crew: Doug Sprouse - fire leader/ignition boss (water and rake) with Nathan White – igniter (drip torch), Erica Taecker – lake-shore igniter (drip torch), and Mickey Matthews – interior igniter (drip torch).

Off-crew: Mike Melnechuk - crew boss/holding boss (water and rake) with Kelly Drey – 2nd water (water and rake), and Justin Zarzeczny – patrol (water and rake).

Ignition begun:	1345; at SE corner
Perimeter rung:	1400; ½ way down west line
Interior ignition completed:	1420.
Interior burnout:	1440.

Fire narrative:

The firelines were prepped the morning of the burn. The west fireline was leaf-blown and raked, and anchored into Tulley Lake. The east line was leaf-blown and anchored into Tulley Lake. Power-poles along the south line were raked around to 2' before the burn. One hour of crew time was spent preparing the unit. All lines were adjacent to FM9. The firelines were all ATV and pumper accessible.

Water was obtained from the PBA fire department the morning of the burn. Due to the small size of the unit, and the accessibility of the lines, no water or DT fuel jugs were staged on the lines. Reserve DT fuel was staged in the pumpers and on ATV's. Both pumpers were staged with flappers, pulaski, extra waterpacks, drip torch fuel, and fire rakes at the SE corner of the unit. Both ATV's were staged with flappers, waterpacks, and pulaskis and used by drag and holding personnel for patrol.

Sprouse obtained a weather forecast from the National Weather Service and made official notifications. The crew prepped the unit. Taecker took onsite weather. A crew briefing was held at 1335 and a test fire was lit at the SE corner at 1345. After five minutes of test fire, with the wind steady and smoke lifting well, the burn was initiated.

A ring fire technique with multiple igniters was utilized. Three igniters started at the southeast corner, with White following the south line, and Taecker igniting the east line and then the north line (lake shore). Matthews ignited the interior of the unit, lagging slightly behind White's ignition. Once the igniters had enough blackline on the east and south lines, they turned the corners and began to light headfire off of the west line. The crews met half-way down the west line, and the unit was rung at 1400, in fifteen minutes. Taecker and White began interior ignition of unburned fuel in the unit. Interior ignition was complete at 1420, and downed woody debris continued to burn into the night. The crew de-staged the unit, a debriefing was given, and the crew departed to burn a bomb storage unit at 1445, with some slash piles still burning and producing smoke. The unit was deemed secure, and a hard frost that evening extinguished all smokers. The unit was cold-out the next day.

No holding problems were encountered on this burn. Smoke was sometimes heavy along the south line (road), but the quick ring-fire and immediate interior ignition alleviated this problem. Backfire flame lengths were 0.5-1.0 feet. Flanking fire flame lengths were 1.5-2.5 feet. Headfire flame lengths were generally around 2-3 feet, torching to 8 feet in areas with downed woody debris.

IMMEDIATE POST BURN EFFECTS- PBA Tulley Lake Unit

Overall unit	Oak/Pine Woodlands
Unit coverage	90%
Burn severity organic substrate	1.2 (scorched)
Burn severity understory	1.1 (scorched)
Char height	1.1 (less than or equal to 5')
Char degree	1.4 (light)
Scorch percent	1.3 (less than or equal to 30% of live crown)
Scorch height	1.1 (less than 10')

By natural community	Oak/Pine Woodlands
Fuel model	9
Coverage	90 %
Organic substrate	1.2 (scorched)
Understory	1.1 (scorched)
Char height	1.1 (less than or equal to 5')
Char degree	1.4 (light - medium)
Scorch percent	1.3 (less than or equal to 30% of live crown)
Scorch height	1.1 (less than 10')

ECOLOGICAL OBJECTIVES

1. Unit coverage 75-95% Total unit coverage was approximately 90%. Areas of lower elevation closer to the lake were patchier, as well as areas near small feeder streams.
2. Substrate burn severity = 1.0 – 3.0. The mean substrate burn severity class = 1.2 (scorched) and ranged from 1.0-2.0. Because much of the unit was near or adjacent to Tulley Lake, substrate burn severity overall was mild. Most plant structures remained intact and above ground. The southwestern corner, which was the furthest from the lake, experienced the most severe substrate burns.
3. Understory burn severity class = 1.0 – 3.0. The mean understory burn severity class = 1.1 (scorched) and ranged between 1.0-2.0. Except for areas near small slash piles and away from the lake, much of the understory was merely scorched.
4. Overstory char height = 0.5-1.5. The mean overstory char height class = 1.1 (less than 5') and ranged from 1.0-2.0. Char height reached and/or exceeded 5' in areas above and away from the lake. There were a few instances in which a slash pile adjacent to a pine resulted in char.
5. Overstory char degree = 0.5-1.5 The mean overstory char degree class = 1.4 (light-medium) and ranged between 1.0-2.0. There was minimal reduction of bark thickness in this unit. Areas that displayed a reduction in bark thickness were those positioned topographically superior to the lake and/or containing slash adjacent to the base of pine as well as juvenile trees.
6. Overstory scorch percent class = 0.5-2.0. Overall overstory scorch percent class = 1.0 (less than 25% of live crown). The moisture of the soil combined with ample root reserves resulted in an overstory scorch percentage of less than 25%.
7. Overstory scorch height class = 0.5 – 1.5. The mean overstory scorch height class = 1.1 (less than 25') and ranged from 1.0-2.0. The only point where the scorch height class reached a 2.0 was in the southwest corner (the furthest corner from the lake). A dense, dry understory combined with parasitic

tree pests may have been the factors that contributed to this exception. Because this burn was of relatively low intensity and there was water nearby, scorch height is expected to be minimal.

THE NATURE CONSERVANCY **FIRE SUMMARY REPORT AND POST BURN EVALUATION**

Site: Pine Bluff Arsenal; 14,944 acres.

Unit: Pond unit; 185 acres.

Date burned: 05 March 2002

Date evaluated: 11 March 2002

Report date: 14 May 2002.

Reported by: Mike Melnechuk

Fire Weather Forecast:

Date:	05 March 2002
Time:	0930
Humidity (low):	30%
Temperature (high):	64°F
20' Windspeed:	10 mph
Wind direction:	south
Sky:	clear
KBDI:	
Comments:	Winds ended up being a little higher than predicted.

Onsite Weather:

Time:	1030	1100	1130	1200	1530
Location:	NE corner	Ignition point	IP	IP	SW
By:	Erica Taecker	ET	ET	ET	ET
Dry bulb:	53°F	56°	57°	57°	63°
Wet bulb:	43°F	45°	45°	45°	50°
Humidity:	41%	39%	36%	36%	38%
Wind speed:	5-10 mph	6-13	10-15	10-15	10
Wind direction:	SW	SW	SW	SW	SW
Sky:	clear	clear	clear	clear	clear

Crew

On-crew: Doug Sprouse - fire leader (water and rake) with Nathan White – igniter (drip torch), Justin Zarzeczny – 2nd water (water and rake), and Mickey Matthews – drag (ATV with water, rake, pulaski, flapper, and DT fuel).

Off-crew: Mike Melnechuk - crew boss/interior ignition (water and rake) with Kelly Drey - igniter (drip torch), and Erica Taecker - patrol (GMC engine with 200 gallons of water, rake, pulaski, flapper, and DT fuel).

Ignition begun:	1210; at North corner (point "A")
Perimeter rung:	1345; ½ way down south line
Interior ignition completed:	1545.
Interior burnout:	1800.

Fire narrative:

The pond unit is located in the Refuge Woods section of the arsenal, and is a 185-acre trapezoidal-shaped burn unit. The unit consists predominately of mature oak-pine woodland (FM9), with about 30 acres of pine savanna (FM2) near the northwest corner, and expanses of mesic to hydric bottomland hardwood forest (FM8) along the south line. The north fireline was a 30'-wide paved road, with additional 20'-wide mown right-of-ways on each side, adjacent to FM9. The NE and east firelines were 10'-wide cut, leaf-blown, and raked handlines through FM8, FM9, and FM2. The south line was a 12'-wide gravel road adjacent to large ponds and FM8. The west line was a 12'-wide gravel road adjacent to FM8 and FM9. The firelines were originally installed two weeks prior to the burn. The northeast and east lines were re-blown and raked the morning of the burn. Power-poles along the north line were raked around to 5' before the burn. 12 hours of crew time was spent preparing the unit. The firelines were all ATV accessible, and only the NE and east lines were not pumper accessible.

Water was obtained from the PBA fire department the morning of the burn. Reserve water jugs and DT fuel jugs were staged on the lines. 10 water jugs were staged on the NE and east handline. Reserve DT fuel containers were staged with one at the NW corner, one at the SW corner, one at the SE corner, and one at the corner of the NE and east lines. Both pumpers were staged with flappers, pulaski, extra waterpacks, drip torch fuel, fire rakes, and chainsaw with PPE at the ignition point of the unit. Both ATV's were staged with flappers, waterpacks, and pulaskis and used by drag and holding personnel for patrol.

Sprouse obtained a weather forecast from the National Weather Service and made official notifications. The crew staged and prepped the unit. Taecker took onsite weather. A crew briefing was held at 1205 and a test fire was lit at the NE corner at 1210. After five minutes of test fire, with the wind steady and smoke lifting well, the burn was initiated.

A ring fire technique was utilized. Two igniters started at the northeast corner, with the on-crew following the NE and east lines, and the off-crew igniting the north line. The on-crew ignition proceeded at a moderate pace, igniting backfire/flanking fire and utilizing perpendicular strips to create a wider blackline. The off-crew proceeded down the north line, heading west, at a moderate pace, lighting backfire and flanking fire, and also using frequent perpendicular and parallel strips to speed burnout in the FM9. The on-crew reached the SE corner as the off-crew made it to the NW corner. The crews turned the corners simultaneously, and began to ignite headfire off the lines. Fire behavior for the off-crew increased significantly in the pine savanna (FM2), but then died out as they made their way to the FM8. The off crew ignition rounded the

SW corner, and continued on the south line, following the FM9/FM8 gradient, until meeting up with the on-crew ignition about half-way down the south line. The unit was rung at 1345, in one hour and thirty-five minutes. Interior ignition commenced immediately, with Melnechuk igniting the east one-half of the unit, and Drey and White igniting the west one-half. Interior ignition continued for another two hours, with very good coverage in the FM9 and FM2, but patchy coverage and mild burning in the FM8. At 1545, the crew began to de-stage the unit and met back at the ignition point (NE corner). A de-briefing was held, and Melnechuk and Sprouse made a final patrol of the lines, while the crew packed up the equipment. With some fire still burning far in the interior of the unit, the fire was deemed secure, and the crew left the site at 1725. Stumps and large woody debris was still burning the next day, and burned until a large rain event put it out during the following week-end.

No holding problems were encountered on this burn. Smoke was sometimes heavy along the north line (road), but the immediate interior ignition alleviated this problem, and visibility remained fair. Backfire flame lengths in the FM9 were 0.5-1.0 feet. Flanking fire flame lengths were 1.5-2.5 feet. Headfire flame lengths were generally around 2-3 feet, to 5' in pine-dominated areas, and torching to 8 feet in areas with downed woody debris. Backfire flame lengths in the FM2 were 1.0-2.0 feet. Flanking fire flame lengths were from 1.5-4.5 feet, and headfire flame lengths ranged from 2.5' in areas of sparse fuels to 12 feet in areas with logging slash and dense woody shrubs. The fire generally did not burn as intensely in the FM8, with occasional exceptions in honeysuckle patches at the edge of the unit, and small debris piles. Flame lengths in the FM8 areas were typically under 1.0'.

IMMEDIATE POST BURN EFFECTS

Overall unit	oak-pine/pine savanna/oak bottoms		
Unit coverage	81%		
Burn severity organic substrate	1.7 (lightly burned)		
Burn severity understory	1.3 (lightly burned)		
Char height	1.5 (less than 10')		
Char degree	1.4 (light)		
Scorch percent	1.0 (less than 25% of live crown)		
Scorch height	1.4 (less than 10')		

By natural community	oak-pine forest	pine savanna	oak bottoms/seeps
Fuel model	9	2	8
Coverage	95%	98%	50%
Organic substrate	1.7 (light)	1.8 (light)	1.8 (light)
Understory	2.0 (moderate)	2.0 (moderate)	1.3 (light)
Char height	1.4 (less than 5')	2.0 (5' - 10')	1.0 (less than 5')
Char degree	1.3 (light)	1.8 (light)	1.0 (light)
Scorch percent	0.9 (less than 25%)	1.0 (less than 25%)	0.0 (none)
Scorch height	1.0 (less than 10')	2.0 (10' - 20')	0.0 (none)

ECOLOGICAL OBJECTIVES

1. Unit coverage 65% -85%. The unit was 81% burned. Unburned areas included seepage areas in the pine-oak woodlands, the oak bottoms at the southwest corner and areas of permanently flooded swamp along the south line. Virtually all the upland oak - pine forest and pine savanna areas burned.
2. Substrate burn severity = 1.0 - 3.0. Overall substrate burn severity class = 1.7 (lightly burned) and ranged from 1.0 - 4.0. The upper litter layer of dry leaves and pine needles was removed in burned areas of the forest. The duff layer was partially removed in pine-dominated areas; and was almost completely removed in areas of ice-damage debris accumulations, otherwise the duff layer was not impacted. Much downed woody debris in the pine-oak woodlands was consumed by the burn. The litter and much woody debris were removed from the area of pine savanna. The oak bottoms were lightly burned, with burn coverage patchy, and in areas that did burn, the leaf litter was mostly removed and the sphagnum moss browned.
3. Understory burn severity class = 1.0 - 3.0. Overall understory burn severity class = 1.3 (lightly burned) and ranged from 1.0 - 3.0. Small trees, vines, and shrubs (to 1" basal diameter) were top-killed in the pine-oak woodlands, and were partially to completely consumed in the pine savanna. In the pine dominated areas that burned hotter (headfire) sensitive and larger diameter woody species will be top-killed. Foliage and smaller twigs were consumed. The bottomland forest litter burned more cool and patchy, but some areas of woody vines and shrubs will be top-killed.
4. Overstory char height = 0.5 - 1.5. Overall overstory char height = 1.5 (less than 5'). Char height averaged about 4' - 6', particularly on pine and was usually less than 3' on the oaks and other hardwoods. This level of char will impact the smaller trees and shrubs located in the oak-pine woodlands. The char height was greater in the pine savanna, and averaged between 5' and 10'. This level of char will not affect the overstory pines due to their size, but will have a significant impact on the young hardwood regeneration in this area.
5. Overstory char degree = 0.5 - 1.5. Overall overstory char degree = 1.4 (light) and ranged from 1.0 - 2.5 (medium). Char was medium trees in the pine-dominated areas and in parts of the powerline with minor reductions in bark thickness. Many saplings will show delayed mortality from this level of char. Char was heavier around piles of downed woody debris and some understory mortality will result.
6. Overstory scorch percent class = 0.5 - 2.0. Overall overstory scorch percent = 1.0 (less than 25% of live crown). The overstory trees in the forest were not scorched and are unlikely to be scorched due to their height. The hardwood and pines located in the savanna and at the edges of the unit were scorched. Due to the season of year the impact of this level of scorch on hardwood saplings is likely to be minor. The number of small pine (to 10') is likely to be reduced by half.

7. Overstory scorch height class = 0.5 – 1.5. Overall overstory scorch height class = 1.4 ($\leq 10'$) and ranged 0.0 – 3.0 (0'–50'). Scorch height ranged for 2' (FM8) to 40' (FM2) in the pine-dominated areas. This level of scorch will result in delayed mortality in small understory trees and saplings. Most of the overstory trees in the forests were not scorched.

All ecological objectives were satisfied by this second burn at the Pond Unit. Unit coverage was much higher than predicted. Consumption of litter, duff, and woody debris was excellent. The reduction in small pine along the preserve edges is as desired. The savanna burned through and much of the small re-spouts and shrubs were top-killed or completely. The fire burned well into the oak bottoms over groundcover dominated by sphagnum and through swamp-edge ferny seeps. Few overstory trees will be affected by the burn. The areas with tree fall gaps will remain open and the herbaceous layer should respond.